

AN AUDIO RESPONSE USER INFORMATION SYSTEM

A Thesis  
Submitted to the Faculty  
in partial fulfillment of the requirements for the  
degree of

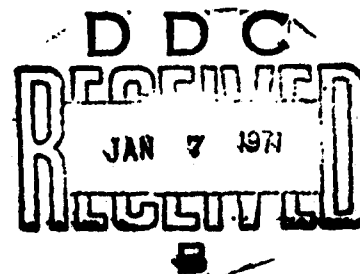
Master of Engineering

by

Garwood Elliott Erickson

Thayer School of Engineering  
Dartmouth College  
Hanover, New Hampshire

June 1970



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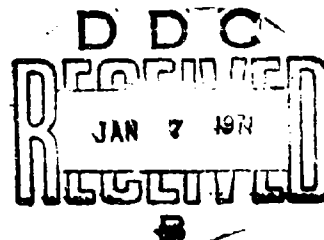
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Garwood E. Erickson  
June 1970

## ABSTRACT

One of the major research programs funded by Project THEMIS at Dartmouth College is the Library Project. This project is concerned with the development of a prototype automated on-line real-time library circulation system connected to the Dartmouth GE-635 time sharing computer. An aspect of this project and the subject of this thesis is the analysis, design and implementation of a library user information system incorporating an audio-response unit. (An audio-response unit is a computer controlled device with a set vocabulary of recorded words and phrases that can be output in any sequence.)

The user information system uses a touch-tone telephone as an input/output terminal. Inquiries are input to the system via a touch-tone telephone button pad and answers are from a computer directed audio-response unit outputting the proper sequence of words and phrases.

A prototype system has been constructed and demonstrated.

## TABLE OF CONTENTS

	Page
Acknowledgements	ii
Abstract	iii
Table of Contents	iv
Table of Figures	vi
Introduction	1
Programmer's Manual	18
Status Byte	19
Output Commands	19
Telephone Data Set	21
Audio-Response Unit	21
Tape Players	22
Interface	23
ARU Vocabulary	25
Maintenance Manual	28
Acknowledge Interrupt	30
Sense Status	30
Audio-Response Unit	31
Data Set	33
Output Commands	33
Read Data	35
Write Data	37
Tape Players	38
Test Program	41
Use of the System in Library Circulation Control	43
Conclusions and Recommendations	50
Bibliography	54

TABLE OF CONTENTS (continued)

	Page
Appendix A	
Notational System	A-1
Interface Board	A-2
Interface Schematic	A-3
Addressing	A-4
DRL's	A-5
Interrupt	A-6
Data Decoder	A-7
Data to ARU	A-8
Status Register	A-9
Data Register	A-10
Output Commands	A-11
Audio Amplifier	A-12
Power Supply	A-13
Appendix B	
ARU Test Program	B-1
Appendix C	
ARU System Demo Program Flow Chart	C-1
Library User Information System Demonstration Program	C-7

# TABLE OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Library Project	2
2	Audio Response Information System	20
3	Tape Player Control Circuitry	24
4	Modified Tape Player	24
5	Interface Board Showing Location of Sub-Assemblies	29
6	Cognitronics Model 674 Speechmaker	32
7	X403A2 Data Set with 801A Handset	34

## INTRODUCTION

The purpose of the library project is "to develop a prototype automated library circulation desk which will eliminate the typical manual procedures used in most libraries, will do so in an economic manner, and will relieve present circulation desk staff of many repetitive clerical tasks while at the same time improving overall circulation service."

"The system is centered on a small computer housed in the library and to which are connected a number of different input-output devices such as a teletype, telephone dataset, a custom high speed charge/discharge terminal and touch-tone telephone audio-response unit. The circulation file will be kept in computer memory; via the various input/output devices books may be charged/discharged (this may even be self-service), holds placed and detected on discharge, renewals and fines processed, notices prepared automatically, searches made on various file variables and simple system statistics compiled."

"As an added and perhaps the most important feature, some of these services can be provided to remote users over the telephone system through the audio-response unit."<sup>24</sup>

A study of the need for an automated circulation information system and the alternative solutions was presented in a preliminary study<sup>23</sup>. A summary of that study follows.

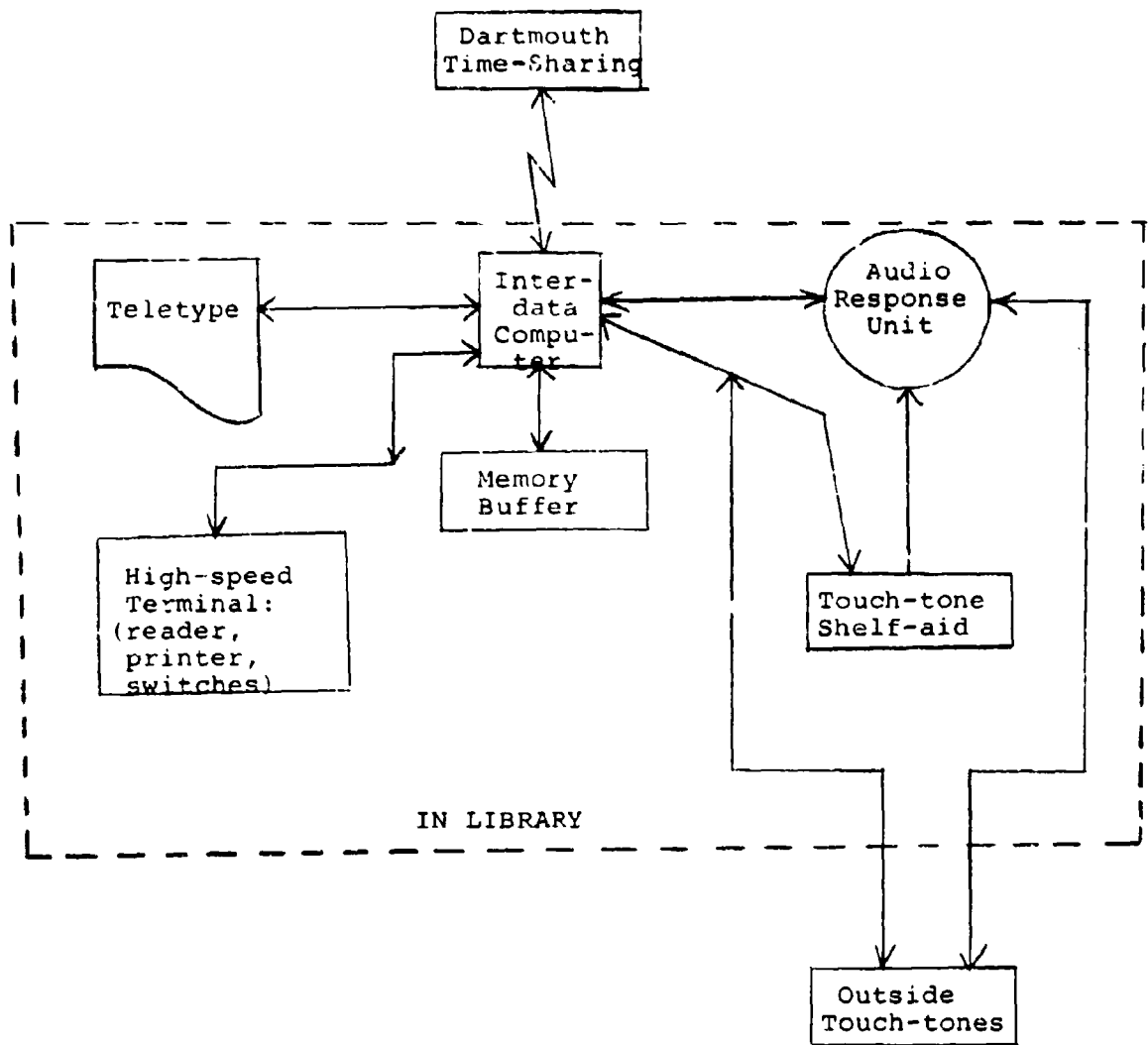


FIGURE 1: Library Project

A circulation information system is an integral part of an operating library. For example, new users can be guided to the location of various books by the librarians. Sometimes a user will need a book that is out. The librarians can reserve the book, or if the user needs the book immediately, the librarians can inform him of the current borrower's name and he can then contact him. A person may need a book for more than the original loan period. If no holds have been placed on the book, the user can renew it at the circulation desk.

Most information systems are at best very casual. The librarians at the circulation desk are there mainly to perform various clerical tasks and partially to answer user questions asked either in person or over the telephone. The librarian often searches the circulation files to learn the answers to the user's questions.

In the prototype library system, without an audio-response unit, the librarians would use the master teletype to learn the answers to users' questions. This system, however, involves attention by professional librarians, attention that could be better applied to jobs necessary to the growth and improvement of the library.

A new system is not necessarily an improvement. Criteria on which a new system can be judged must be listed. The following criteria will be used in evaluating and comparing proposed new systems.

First, is the suggested system practical? Can we make

the system work within the constraints of available time and skill? Hopefully a prototype system will be operative within a year.

Second, does the proposed system involve an economy of human effort? Is the proposed system as easy to use or easier to use for both the librarians and the users as the present system? The present system is available to remote users, therefore the proposed system must also be available to remote users.

Third, and final, does the suggested system involve an economy of dollars? If we invest extra money in a new system, will it save enough dollars in operating disbursement over time to produce an acceptable return on the investment?

Each system will be weighed according to the above criteria, and the best alternative selected.

The present system as described earlier, is a working computerized library circulation system. A librarian uses the master teletype to query the circulation files in order to learn the answers to users' questions.

Some type of input-output device will be necessary to input questions to the system, and output answers to the user. Input-output units available on the market today include keyboard input/printer output devices such as a teletype<sup>7</sup> and various touch-tone oriented input devices.

These input/output terminals could be provided to each potential user in the service vicinity of Baker Library. This would satisfy criterion number two, that information

service be available to remote users. However, the cost of a teletype, or a cathode ray display for all remote users would be prohibitive. Model 33KSR teletypes rent for \$70 per month, and cathode ray displays even more. Any remote terminal other than a touch-tone telephone involves extra cost for the user<sup>8,10,11</sup>. Teletypes or cathode ray displays located at selected locations would be impractical because of cost, and unacceptable to the criterion that the system involve an economy of human effort. A user would have to expend some extra effort to reach a remote terminal. Another alternative is using teletype or cathode ray display near the card catalogue in the library. This would eliminate in-person inquiries to the librarians. Remote users could still call the librarian. This system satisfies criteria numbers one and two.

The other input/output device not yet mentioned is the touch-tone telephone<sup>8,10,11</sup>. Information can be input using the touch-tone buttons and the output can be voice from an audio-response unit directed by the small computer. This alternative satisfies criteria one and two.

Each of the above suggestions was analyzed further than suggested above. The last described system with touch-tone input and ARU output will be discussed in greater detail below to present the system and to exemplify the analyses used on all proposed systems. This system is shown in block diagram form in Figure 2.

Since this is a user information system, the first area

of interest is the kind of information and services that can be made available to the user. The limiting factors are the size of the vocabulary of the audio-response unit, and the raw information available from the computerized library system.

The maximum vocabulary size that can be justified economically is sixty-three words, available on the Cognitronics Model 674 Speechmaker. The raw information available from the library system includes the call numbers of borrowed books, the borrower identification numbers, the due dates, and the identification numbers of persons who have placed holds on a particular book<sup>19</sup>.

Information on which stack a certain book is in can be determined by comparing the book number with a table in the computer.

From the raw data it can be determined whether the book is in or out or lost, the stack number, the due date, and the borrower identification number. Also, this information can be updated if a user renews a book he has out, or places or releases a hold on a specific book.

Hardware alternatives were the second area of study.

Bell Systems is slowly replacing all dial telephones throughout the country with touch-tone telephones. Hanover should have them January 1971, and 95 percent of the country within eight years (according to the Claremont, New Hampshire, business office of the New England Telephone Company). A touch-tone telephone has ten or twelve push buttons instead

of a rotary dialer. On the twelve button telephone, the extra buttons are labeled \* and #<sup>20</sup>.

As a data input terminal, the touch-tone telephone has several advantages over all other data input/output devices<sup>3,10,11</sup>. It is the lowest cost such unit on the market today. It costs \$5 to install and rents for \$8.25 per month. It has the advantage of being multipurpose. It can be used as a normal telephone, and as a data input/output terminal. In the library system it has an extra cost of zero to the user because presumably the touch-tone telephone will be his normal telephone.

A disadvantage of touch-tone telephones is the limited number of input keys. To input anything besides numbers, one must devise a code involving multiple keying. The best code will depend on whether the ten button or twelve button telephones are used. With the library system, the capability to input digits, letters, and a decimal point must be provided because book numbers are a combination of letters, digits and decimal points.

One alternative is to use a two digit code, such as 34 for the digit 4, and 07 for the letter G. Another alternative is to provide a shift key or code to signal a switch from letter to digits, and back. Then 0 to 9 could represent the digits and 01 to 26 the letters.

On a twelve button telephone one of the extra buttons could be used to signal a shift from the digits to numbers or vice versa. Perhaps one of the extra buttons could signal digits following, and the other could signal letters following.

On a ten button telephone it would be more awkward to have a shift key. A shift code such as 33 could signal a change but this would only allow a slight modification of the code (01 could represent either the digit 1 or the letter A), and would probably be confusing to the user.

The actual decoding will, at any rate, be under software control, and the flexibility of the system allows experimentation with different systems to determine the one most convenient for the user.

Examples of possible codes for the ten button and the twelve button telephones are listed below.

#### Examples of Input Code

##### Twelve Button Telephone

+ letters following	
- digits following	+ shift
0 to 9 digits	0 to 9 digits
01 to 26 numbers	01 to 26 numbers

##### Ten Button Telephone

33 shift	
01 to 26 letters	01 to 26 letters
01 to 09 digits	30 to 39 digits

To convert the tones we received over the telephone line to usable data, some electronic data converter must be used. Telephone company regulations require the electronic equipment (such as telephones or Data Sets) at each end of their

telephone lines meet certain rigid specifications. According to them, this is to protect their switching equipment from being electronically damaged by a faulty unit at one end of the line. Design requirements are such that the design and construction of one unit would cost much more than units commercially available. Several suitable Data Sets are available on the market today; these include the IBM 3975, and the Bell Systems X403A2, 401J3, 403D, and 403E.

The Bell Systems X403A2 rents for \$50 per month and has a \$50 installation charge. The Data Set provides an interface between the telephone company equipment and the user's equipment. The X403A2 automatically answers incoming calls, and returns a tone to the user indicating that the phone has been answered. In addition it converts the incoming signals from the touch-tone telephone into a two out of eight binary code, and indicates disconnection by the system user<sup>20</sup>.

A computer is already part of the library system, but knowledge of its capabilities and limitations is essential in designing the library user system. The Interdata Model 3 computer is a general purpose digital computer with a 2  $\mu$  sec memory cycle time, and a core memory of 8192 bytes<sup>21,22</sup>. This computer will act mainly as a message switching center between the library devices (including the data set and the audio-response unit) and the GE 635 time-sharing system. It will read the data from the dataset and then format an inquiry to be sent to the time-sharing system. Upon reception of an answer from the GE 635, it will formulate a series of instructions to be written to the audio-response unit. These

instructions will control the audio-response unit and will typically drive it to output a verbal message to the user through the dataset.

An audio-response unit, or voice response unit, is a device with a fixed vocabulary of words and phrases that can be output from the unit in any order, as directed by a computer, and can be converted into intelligible audio. The ultimate goal in designing an audio-response unit is to provide a natural sounding reply with all the proper inflections and pauses, no matter what order one may decide to call out the words. However, the necessary requirements are not as rigorous as this. Voice quality need only be intelligible. The time between words can be noticeable and slightly unnatural, but not disconcerting. Also, inflections can be the same for each word. This will produce a stilted, but not unintelligible message<sup>18</sup>. The unit must be designed for long life with minimum maintenance. The final output of the unit must be an analog signal, but it can be stored in analog or digital form.

There are many alternatives for audio-response units. The following will discuss these alternatives and then attempt to reach valid decisions as to acceptable alternatives. All audio-response units must have a stored signal representing each word, a storage medium, a pickup device, and logic to select the proper word.

The signal representing the word can be stored either in analog or digital form. Much research has been done by

Bell Laboratories in the field of digital representation of voice sounds<sup>2,4</sup>. The basic hardware unit is called a vocoder (for voice decoder), basically a sophisticated digital to analog converter that produces voice output from digital input<sup>2,3,4,5,12,13,16,17,18</sup>. It appears from these articles that an audio-response unit along these lines would be more expensive than a unit using a stored analog signal. Both systems require a storage unit, and pickup devices. In addition, the digital system requires some sort of digital to analog converter to produce the analog signal as output<sup>17</sup>.

The basic requirements for an analog voice-response unit are a storage device, a method of picking up the stored signal, and logic to pick the right track and thus the right word off the storage unit.

There are three popular methods for storing analog signals, and then reproducing them later. They are a magnetic storage medium and pickup head, a grooved medium such as a record of Dictaphone belt and a needle, and a transparent film and a photoelectric cell. Which of the above devices is used depends mainly upon the economics of the units with much attention being paid to the wear of the storage medium and subsequent deterioration of the stored signal caused by the pickup device and the medium.

On the market today there are basically only two different audio-response units. They are made by Cognitronics and IBM. Other companies, namely RCA, UNIVAC, Honeywell, Burroughs, and General Electric, use the Cognitronics unit

as the basic response unit.

Using the criteria given earlier, the Cognitronics 674 Speechmaker appears to be the best alternative. Home built models have been rejected because of the design and time costs involved, and the question of practicality. There is also some question as to whether such a unit could be built and perfected within a year. A vocoder has also been rejected for the reasons listed earlier in this section. The Model 632 Cognitronics Speechmaker was rejected because of insufficient vocabulary. The IBM unit was rejected because of cost. (It sells for around \$60,000.)

There are two problems not yet covered in the previous pages. One is the problem of supplying a verbal introduction when the phone is answered and supplying lengthy instructions to a new user. The other is the problem of delay in obtaining information from the time-sharing system.

A user unfamiliar with the system must receive instructions on how to use the system. In order to facilitate use from any touch-tone telephone, these instructions must be given to him over the telephone. It would be uneconomical to use the audio-response unit to produce these instructions when we could use another audio producing unit such as a tape recorder with a long tape loop. There are units commercially available which stop automatically at the beginning of the loop. The computer can be programmed to skip the instructions if the user so desires.

Design criteria for the long message units are: independent operation, simplification of computer control commands,

variable length messages, and ease of modification of the messages. Schemes to use various tracks on one tape recorder do not meet all the criteria. Reel recorders require rewind and fast forward commands. Cartridge tape players are endless loops and do not have fast forward controls. In addition, an automatic stop control within the player eliminates the need to stop the player under computer control.

A user waiting for a reply might have to wait 20-30 seconds before he hears a reply because of the delays inherent in the time-sharing system. To prevent him from becoming impatient or worried at the delay, music will be played to him to indicate that the system is operating.

Any system has occasional errors. They might be the fault of the user, the computer, or the telephone system. The user can be used to correct most of these errors by using an audio feedback system that tells the user what the computer thinks he input.

There are at least two methods of implementing this error checking system. The system might respond after each letter or digit has been input. If the response is not as desired, the user could delete the previous input and replace it with the correct one by inputting the error code. Or, the audio-response unit might respond with a long message after an entire line has been input. This would make correction harder, but would shorten the delay between input and answer.

In any of the above systems, the user must have some way of correcting an error. Either a special code, or one of the extra buttons on the twelve button telephone could be used to indicate an error.

In any case, the programmer has complete freedom to use any method he desires, and can experiment with any system by changing the software.

In order that the computer can communicate with the audio-response unit, the Data Set and the tape recorders, the interface has to be designed and built to be as general as possible in order not to constrain the software design and implementation<sup>21,22</sup>.

An analysis such as above for all proposed systems produced three alternatives that met criteria one and two (practicality, and ease of operation). These three will now be compared using criteria number three. Does the proposed system involve an economy of dollars?

The first alternative is the present user information system, a librarian using the master teletype of the system to learn answers to users' questions.

Consultation with several librarians at Baker determined that they spend about one-third of their time answering the questions and performing the services that the proposed system would handle. The librarians are paid \$1.90 to \$2.50 per hour depending on experience and training, with the mean about \$2.25 per hour. The library is open Monday to Friday from 8:00 AM to 10:00 PM for a total of 87 hours a week.

Annual disbursements for providing information are, therefore, \$3595.

The second alternative is adding an extra teletype to be located near the card teletype in the library for the use of library users. This would eliminate in-person inquiries to the librarians. The librarians estimated that of the time spent answering questions the proposed system will answer, half of it is spent answering users' questions over the telephone. The other economic factors are the same as alternative number one. The teletype rents for \$70 per month. Annual disbursement for providing information with this system are \$2637, and a teletype interface costs \$2000 from Interdata.

The third alternative is the audio-response unit and the touch-tone telephone. The Cognitronics Model 674 Speechmaker, mounted and powered costs \$8335. The vocabulary film cylinder adds \$1320. The X403A Data Set costs \$50 to install and rents for \$50 per month. A touch-tone telephone, to be located near the main circulation desk in the Baker Library, costs \$5 to install and rents for \$8.25 per month. The interface between the audio-response unit, the Data Set, and the computer was estimated to cost \$900. This breaks down into design costs \$500 (200 hours at \$2.50 per hour), hardware \$300 and assembly and testing \$100 (40 hours at \$2.50 per hour).

Tape player costs were estimated at \$300. Because of their limited use in the system, an economic life of ten

years is a reasonable estimate. Cognitronics Corporation estimates the physical and economic life of their Speechmaker at ten years, with a zero salvage value at that time. Maintenance is limited to monthly cleaning of the air filter and will be estimated at \$25 per year. Software development for the system was estimated to cost \$500 (200 hours at \$2.50 per hour).

Total initial investment is estimated at \$12,000. Annual disbursements would be \$725 per year.

From the above figures the time scales comparing alternatives look like this.

Status Quo	Annual Disbursement = \$2637	10 years
Extra Teletype	Annual Disbursement = \$2637	10 years
Initial Investment = \$12,000		
Audio-Response System	Annual Disbursement = \$725	10 years

Comparing the alternative of the status quo with the alternative of the audio-response system, the extra investment of \$12,000 is recovered in saving of annual disbursement at a rate of 21 percent. Comparing the alternative of the extra teletype with the audio-response system, the extra investment of \$12,000 is recovered in savings of annual disbursement at a rate of 15 percent.

These rates of return indicate the audio-response system is the best economic alternative.

As a result of this study, it was estimated that an automated circulation information system could be designed and a prototype system could be constructed within one year for a cost under \$12,000. This system was designed and built. The remainder of this thesis is devoted to describing in detail the design, maintenance and use of the system.

PROGRAMMER'S MANUAL

This section is written as a guide to the programmer who may wish to use the hardware developed as a result of this thesis. The programmer should be familiar with the Interdata 3 Reference Manual<sup>21</sup>.

The Interdata computer has been designed to handle external interrupts efficiently. The programmer enables external interrupts and tells the computer the address of the first instruction to be executed after an external interrupt. The computer does the rest. When an external device interrupts, the computer finishes processing the instruction on which it was working, stores the address of the next instruction it would have processed if there had been no interrupt and branches to the instruction specified above by the programmer. An acknowledge interrupt instruction should be the next logical step. Status is read automatically and placed in a general register. Based on which bits are set in the status byte, the program will probably branch to a specific subroutine. This subroutine should merely handle housekeeping chores, such as reading data, or issuing an output command. Any long calculations should be done after enabling external interrupts.

The status byte is as follows:

<u>Bit Set</u>	<u>Meaning</u>
0	ARU ready for next word
1	Data was input from the telephone
2	Tape player one finished
3	Tape player two finished
4	User hung up
5	New user on line
6	Unused
7	Unused

There are 12 possible output commands. These and their hexadecimal equivalents are listed below:

	<u>HEX</u>	<u>BINARY</u>
Enable answering	E	1110
Disable answering	6	0110
Enable ARU	3	0011
Disable ARU	B	1011
Enable 1 digit input	C	1100
Enable 2 digit input	4	0100
Enable Data input	2	0010
Disable Data input	A	1010
Start Tape Recorder 3	1	0001
Stop Tape Recorder 3	9	1001
Start Tape Recorder 1	5	0101
Start Tape Recorder 2	D	1101

The interface built for this thesis enables communication between the ID-3, and a telephone data set, an audio-response unit, and three tape recorders (see Fig. 2).

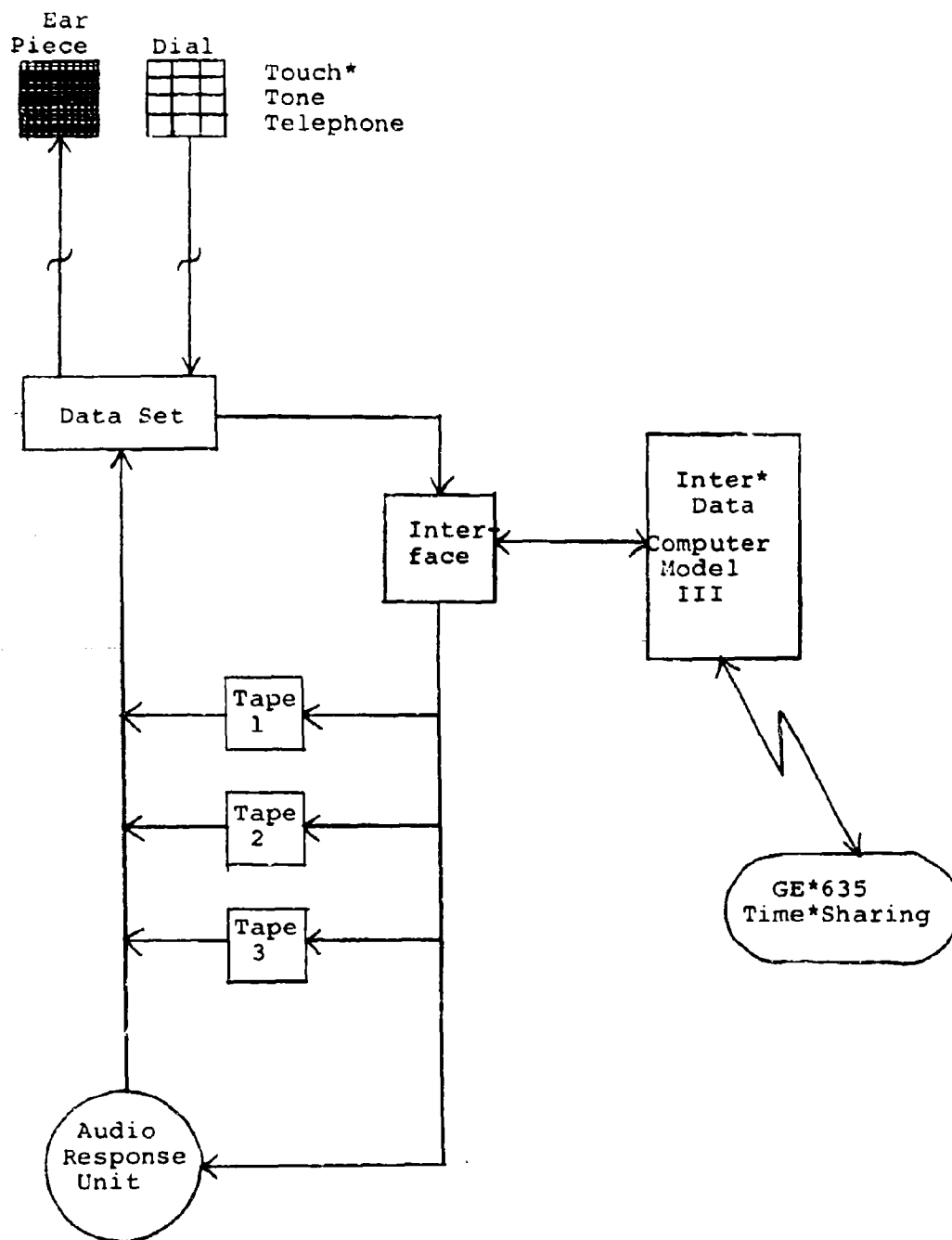


FIGURE 2:  
Audio Response Information System

### Telephone Data Set

The telephone data set is an X403A2<sup>20</sup>. It can automatically answer incoming calls, and convert the tones generated by a user pressing a button on a touch-tone telephone into digital logic signals. The programmer must enable automatic answering mode by issuing the appropriate output command to the interface. This allows the programmer to control when the system will allow connection by users. If automatic answering is not enabled, the user will only hear repeated ringing as if no one were at home. The data set, after automatically answering a call, will return a two to five second 2000 cycle tone to the user, and then tell the ID-3 through an interrupt that a user is on line.

The data set operates in a half-duplex mode. Either data can be input by the user, or he can hear audio output, but not both. The programmer must enable data input to receive data from the user, or disable data input to play audio back to the user.

In addition to the above, the data set will indicate, via an interrupt, user disconnection.

### Audio Response Unit

The audio-response unit's logical operation is straightforward. The programmer enables ARU interrupts, and upon reception of an ARU interrupt writes the address of the next track to be played. The interface has been designed to allow the program 625 milliseconds to respond to an ARU interrupt.

The ARU interrupt signals a request for another track address. Due to the above timing considerations, a message should always end with two silent words, track address 0. This ensures reception of the entire message by the user. Normal programming practice will be the enabling of data input immediately after the last track address has been written to the ARU.

#### Tape Players

The tape player units are of two types. Two are designed as long message units. When in the "off" state, each will have its reading head positioned at the beginning of its message loop. The programmer issues an output command to turn on one of the players. When the player completes the playing of its loop, it sends an interrupt back to the computer and then halts. The third player is designed to play music or a repetitious message such as "Just a second please." The programmer issues an output command to either instantly start or stop the player.

The programmer can make a few minor hardware adjustments. The lengths and types of messages played by the tape players can be easily adjusted. Also, the volumes of the ARU and the tape players can also be easily adjusted.

Tape cartridges can be purchased with any length of tape desired by the programmer. If one message is to be 45 seconds long, then the length of tape purchased should be 46 seconds long including the one second of tape necessary to allow the motor to reach full speed on start up and to stop

completely. A modified tape player is shown in Fig. 4.

To record a message use the microphone provided. First, align the tape by turning the tape recorder on and allowing it to run until it stops automatically. The tape recorder is turned on by outputting the proper command through the computer; the following program can be used:

<u>Address (Hex)</u>	<u>Contents</u>
300	LHI 5, X' 11'
304	LHI 6, X'5' or X'D'
308	OCR 5, 6

Immediately after starting the player, press the record button, and begin recording the message.

The playback volume levels of the tape players can be varied by turning the screws on the three adjustable potentiometers located on a vector board next to the tape recorders. Clockwise increases the volume, counterclockwise decreases it (see Fig. 3).

### Interface

The interface was designed to allow the programmer maximum freedom in coding, and to decrease the amount of programming necessary to operate the system. Use of the interrupt scheme allows independent operation of the five devices connected to the interface. The ability to enable and disable interrupts eliminates the extensive programming that would have been required to determine exactly what the five

Volume Controls

1 2 3

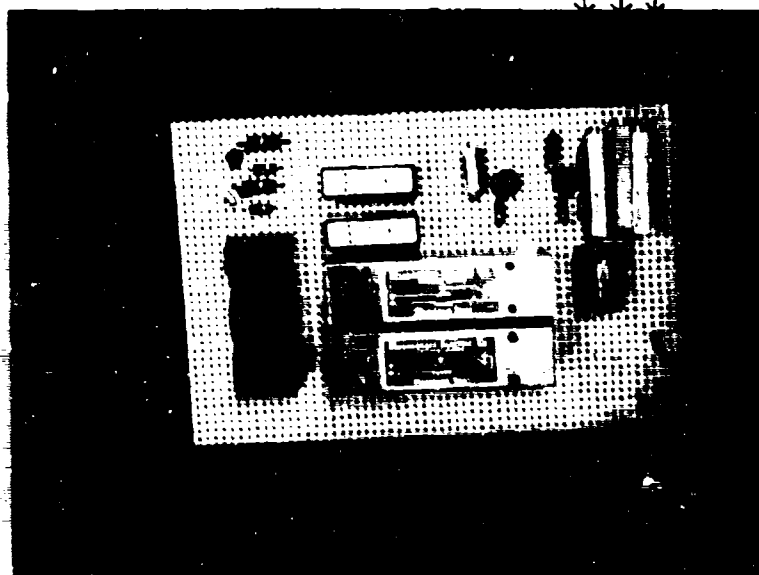


FIGURE 3: Tape Player Control Circuitry

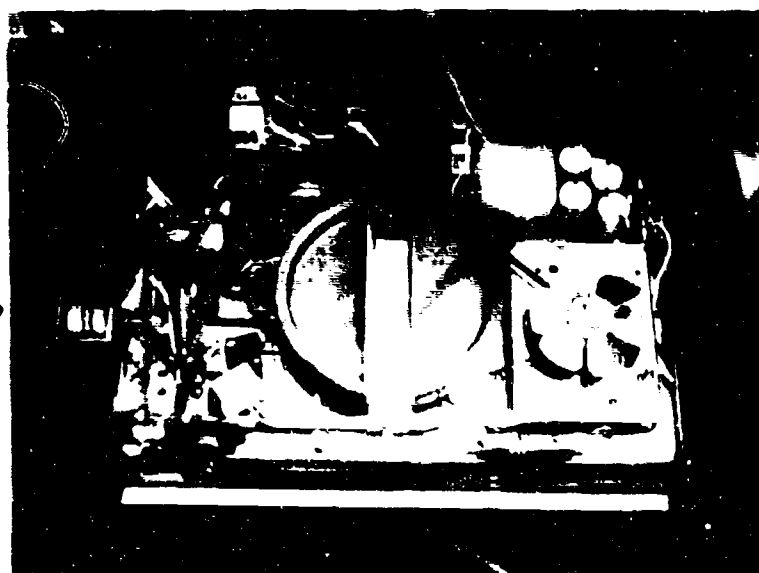
Control  
Solenoid →

FIGURE 4: Modified Tape Player

components were doing. Extraneous, or unexpected interrupts are eliminated, because they can be disabled, and thus cannot get through.

The data set returns a 2 of 8 code to the interface. A decoding matrix converts this to binary code. The programmer has the option of allowing one digit or two digit input before an interrupt is returned. This ability allows elimination of long coding in applications in which a two digit code is necessary, but does not restrict the programmer to the two digit code for every application.

The basic logic scheme of this system is to enable a device, receive the interrupt from the device indicating it is ready and then act upon that interrupt. The type of interrupt indicates the subroutine necessary to handle it. Extensive flagging is thus eliminated. This is an asset in any computer but especially in one with a small memory such as the Interdata 3.

#### ARU Vocabulary

The ARU vocabulary has been chosen to convey maximum information in a minimum amount of words. Economic considerations produced a 64 word maximum vocabulary, and the information to be returned determines the exact vocabulary necessary.

The following is a list of the responses as they are recorded on the 63 tracks of the Cognitronics unit:

<u>Track Number</u>	<u>Word or Phrase</u>
0	Silence
1	A
2	B
3	C
4	D
5	E
6	F
7	G
8	H
9	I
10	J
11	K
12	L
13	M
14	N
15	O
16	P
17	Q
18	R
19	S
20	T
21	U
22	V
23	W
24	X
25	Y
26	Z
27	January
28	February
29	March
30	0
31	1
32	2
33	3
34	4
35	5
36	6
37	7
38	8
39	9
40	Point
41	April
42	May
43	June
44	July
45	August
46	September
47	October
48	November
49	December
50	Error

<u>Track Number</u>	<u>Word or Phrase</u>	(continued)
51	Book	
52	is in	
53	is out	
54	is lost	
55	A hold	
56	has been	
57	Placed	
58	Released	
59	Due Date	
60	Borrower	
61	Return	
62	Stack	
63	Renewed	

As an example, the audio-response unit could inform the user which stack a book is in by using a digit, "Book is in" and "stack number" to tell the user "Book is in stack number 5".

MAINTENANCE MANUAL

To enable communications between the Interdata computer, the data set, the audio-response unit and the three tape recorders, a device controller, or interface, was designed and constructed. The main design criterion was to make the design general to prevent constraining the software implementation. Integrated circuitry was used extensively to enhance reliability and speed of construction.

It was decided early in the design that only one device controller would be built to handle the data set, the audio-response unit, and the three tape recorders. To the computer these five devices would appear as one machine. Because of the asynchronous nature of these devices and the general design of the library system, the device controller would signal the computer its desire for attention via the external interrupt structure<sup>21</sup>. The nature of the service desired is indicated by the status byte.

Refer to Page 6 of the Interface design (Appendix A). There are six possible types of interrupts: 1) the timing pulse from the audio-response unit, 2) user on line, 3) disconnection, 4) data from the Data Set, 5) tape recorder 1 finished and 6) tape recorder 2 finished. Each of these can independently generate an interrupt, if the computer has previously enabled interrupts from these devices. Each type of interrupt sets a specific flip-flop which is read whenever Sense Status is performed by the computer. The reader should be familiar

NOT REPRODUCIBLE

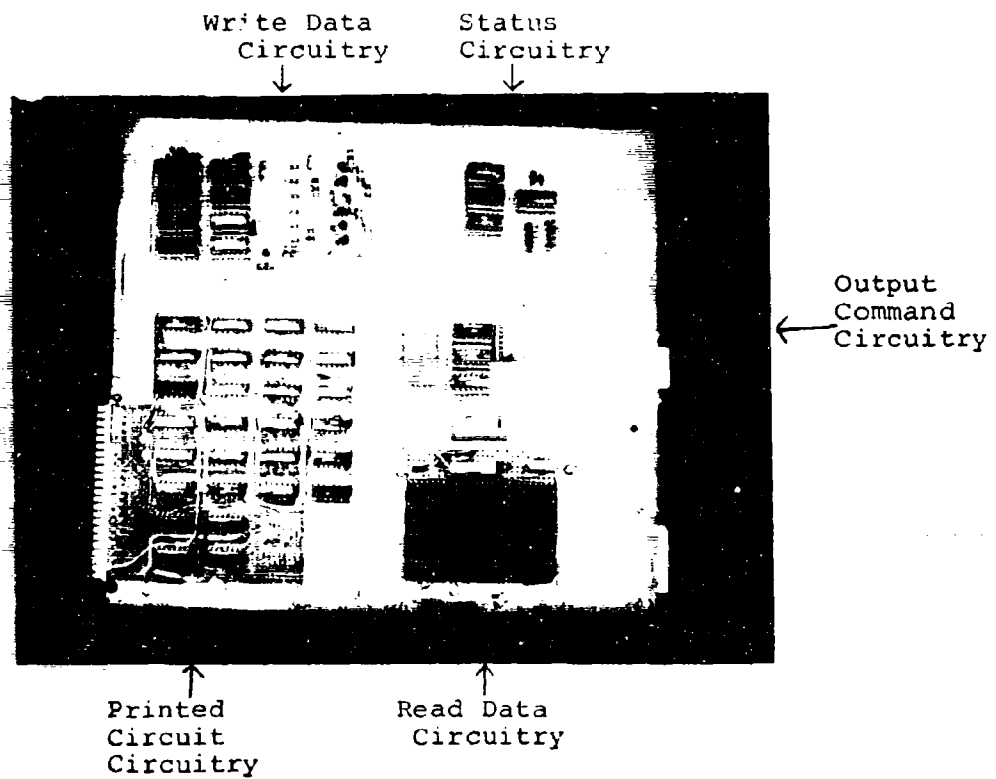


FIGURE 5:  
Interface Board Showing Location  
of Sub-Assemblies

with the Interdata 3 Interface Manual<sup>21</sup>.

#### Acknowledge Interrupt

After the generation of an interrupt by the device controller, an acknowledge interrupt will probably take place. Refer to Page 3 in the interface schematic.

1. ATNO is sent to the computer.
2. The computer responds by raising RACKO.
3. RACKO and Q from the interrupt flip-flop are NANDed together to send back to the computer and enable the device number onto the Data Request Lines DRLO00 through DRL070 (see Page 3 of the schematic).
4. The computer lowers RACKO, which in turn causes SYNO to be lowered.
5. The computer then starts the Sense Status Sequence.

#### Sense Status

Sense Status enables the computer to determine which of the six possible conditions caused the interrupt. Refer to Pages 1 and 6 of the schematic (Appendix A).

1. The device number is placed on the Data Available Lines, DAL000 through DAL070, and is decoded by the address decoder.
2. ADRSO is raised by the computer.
3. The NANDing of ADRSO and DD1 (from the address decoder) sets the address flip-flop.

4. ADSYO is sent back to the computer and DENB1 goes high.
5. Upon reception of ADSYO, the computer lowers ADRSO and removes the device number from the DAL lines. The interface then lowers ADSYO.
6. SRO is raised by the computer.
7. SRI NANDed with the status byte causes the status byte to be sent back to the computer. At the same time, SRSYO is sent back to the computer.
8. Upon reception of SRSYO, the computer gates the status byte to the proper address, and lowers SRO. This causes the status flip-flops to be cleared and SRSYO to be lowered.

#### Audio Response Unit

The Cognitronics Model 674 Speechmaker requires an input of six bits of information in parallel to specify which of the 64 words or phrases should be output. These six bits must be placed on the input lines of the Cognitronics unit at the start of the word or phrase and remain on these lines for the duration of the word or phrase. The Speechmaker provides a timing pulse of 30 milliseconds duration to indicate to the computer the start of a new word or phrase. The output from the Speechmaker goes to the voice answer back terminal of the Data Set.

NOT REPRODUCIBLE



FIGURE 6:  
Cognitronics Model 674 Speechmaker

### Data Set

The Data Set<sup>20</sup> delivers contact closures to the Interface. An incoming call is automatically answered if the Data Terminal Read Lead is closed to ground. The Data Set then automatically answers an incoming call, and returns a two to five second tone to the user. The Data Set signals that a call has been answered by closing the Data Set Ready Lead to ground. To send voice back to the data set and thus to the user, the Data Receive Lead must be released from ground.

### Output Commands

After determining the nature of the interrupt from the status byte, the computer will probably issue some output commands to the interface. The possible output commands are: 1) enable and disable audio-response unit interrupts, 2) enable and disable answering, 3) enable one digit input, 4) enable two digit input, 5) turn tape recorder number three on or off, 6) turn tape recorder number one on, and 7) turn tape recorder number two on.

The output command sequence follows. Refer to Pages 1 and 8 of the schematics (Appendix A).

1. The interface is addressed exactly as in steps 1-5 of the sense status description.
2. The computer puts the command on the DAL lines.
3. CMD0 is raised by the computer.
4. CMD1 is NAnDED with DENB1 to enable the command on the DAL lines to be decoded by the 1 of 16 decoder

NOT REPRODUCIBLE

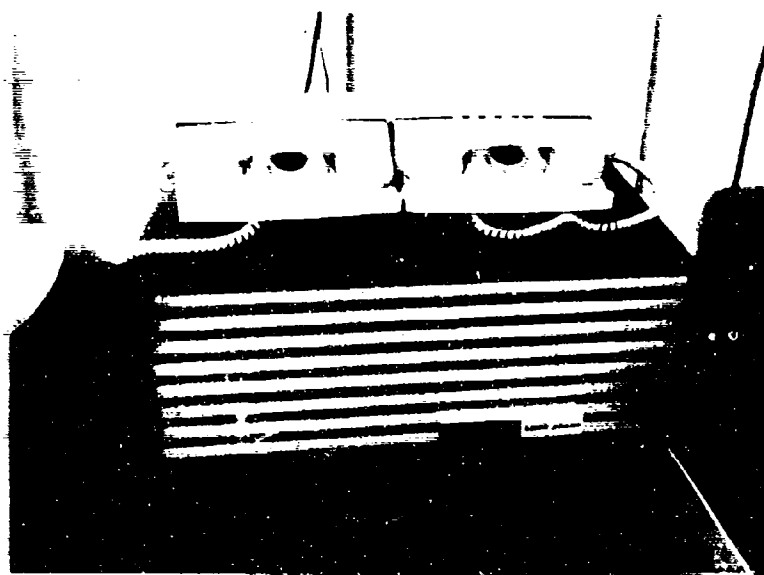


FIGURE 7:  
X403A2 Data Set With 801A Handset

and set or reset the proper flip-flop. At the same time CMSYO is returned to the computer.

5. The computer then lowers CMDO and removes the command from the DAL lines.
6. The interface then lowers CMSYO.

Setting FF1 enables the audio-response unit interrupts. Q of FF1 is NANDed with the timing pulse from the audio-response unit to send off an interrupt. This timing pulse does not get through if FF1 is cleared. Enabling "one digit input" (from the touch tone telephone) sets FF2. Enabling "two digit input" resets FF2. Further details are presented in the read data section of this discussion. The data set interface specifications<sup>22</sup> require a contact closure between signal ground and the Data Terminal Ready Lead to set up the data set for automatic answering of incoming calls. Setting FF4 enables answering by turning a power gate on which in turn causes current to flow in the coil of relay R1, and close the Data Terminal Ready Lead to ground. Data is enabled by setting FF3 which closes the data receive ready lead to ground by activating R2. When Data receive is disabled the telephone line is connected to the dataset answer back circuitry.

#### Read Data

If the status byte indicated that the dataset has data, the ID-3 is expected to enter into the read data sequence. Refer to Pages 7 and 2 of the schematic (Appendix A).

1. The device controller is addressed as in steps 1-5 above.
2. DRSYO is raised by the computer.
3. DF1 Nanded with DB01 through DB71 causes the data to be sent back to the computer. At the same time DRSYO is sent to the computer.
4. Upon reception of DRSYO, the computer gates the data to the proper address and lowers DRO. The interface then lowers DRSYO. The lowering of DRO resets the counter flip-flop.

When a touch-tone button is pushed, the data set encodes the number into a two of eight code. One of four A lines and one of four B lines are closed to ground for 50 msec. The two of eight code is listed below.

<u>Contacts Closed</u>		<u>Touch Tone Button Pushed</u>
A <sub>1</sub>	B <sub>1</sub>	1
A <sub>1</sub>	B <sub>2</sub>	2
A <sub>1</sub>	B <sub>3</sub>	3
A <sub>2</sub>	B <sub>1</sub>	4
A <sub>2</sub>	B <sub>2</sub>	5
A <sub>2</sub>	B <sub>3</sub>	6
A <sub>3</sub>	B <sub>1</sub>	7
A <sub>3</sub>	B <sub>2</sub>	8
A <sub>3</sub>	B <sub>3</sub>	9
A <sub>4</sub>	B <sub>2</sub>	0

The circuitry on Page 4 converts the 2 of 8 code into binary and sends a data on line indicator. The presence of up to one msec of contact bounce, and up to 200 msec delay between

A closure and B closure necessitated a delay in the toggling of FF8 after the first contact closure of slightly over one msec. This was accomplished by placing a 1.33 uf capacitor between ground and the data on lines 1 line. This signal then toggles FF8. The first input signal sets FF8. The change of  $\bar{Q}$  from + 5V to 0 volts strobes data into FF4 through FF7. See Page 7 of the interface schematic.

The purpose of FF8 and the circuitry on the bottom right quarter of Page 7 is to allow the programmed controlled option of either one or two digit input per interrupt. If only one digit input is desired, the presence of  $\bar{Q}$  at + 5 volts and "data on lines" =1 will send off an interrupt. If two digit input is enabled,  $\bar{Q}$  RETURNING TO + 5 volts ensures that FF8 is reset after each interrupt.

#### Write Data

If the interrupt was from the audio-response unit, the computer is expected to execute a write data instruction to tell the audio-response unit which word to output. Refer to Page 5 of the interface schematic (Appendix A).

1. The device controller is addressed as in steps 1-5 of the sense status description.
2. The computer places the data on the Data Available Lines DAL000 through DAL050.
3. DAO is raised by the computer.
4. DAL is Nanded with DENB1 to enable DAL01 through DAL51 to set the first line of number flip-flops.

At the same time DASYO is sent to the computer.

5. DASYO causes the computer to lower DAO, and this in turn causes the device controller to lower DASYO.

Data is read into FF1 through FF6 by DAG1. The timing pulse from the audio-response unit strobes the data from FF1 to FF6 into FF7 to FF12, and then clears FF1 to FF6. The double buffer allows the computer up to 625 msec to respond to an interrupt from the audio-response unit. If there were only one buffer, the computer would have to write data to the audio-response unit within 30 msec after receiving an interrupt. The timing pulse is used to clear FF1 to FF6 so that at the end of a message or if the computer did not respond within 25 msec, the user would hear silence, not the last word repeated two or more times. The Interdata computer and thus most of the interface uses 0 volts as a logical 0, and a 0 volts as a logical 1. The discrete elements after FF7 to FF12 are used to convert the logic levels. The timing pulse coming from the Speechmaker had to be converted, but in the reverse direction. It is then differentiated by C3 and C2 to strobe data from FF1 to FF6 into FF7 to FF12. The pulse differentiated by C3 is delayed by C1 for 100 Nanoseconds and then clears FF1 through FF6 by strobing in zeros.

#### Tape Players

There are three cartridge tape players in the system. Two are Sony TC-8 play-recorders with an automatic stop

feature and one is an Automate Radio player. Slight modifications were necessary to produce computer controlled operation.

The AR unit plays music. To prevent the user from hearing wow and flutter during the stopping of the tape player, the audio is switched off just as the motor is switched off. The motor starts almost instantaneously but glides to a stop. If the audio were left on, the user would hear the tape come to a stop. Two Magnecraft W102NRMPGX-1 SPST relays were used to control the motor and the audio switches. The output command 0001 sets FF5 which turns a power gate on and closes R3 and R4. The output command 0009 resets FF5, and thus turns the music off. See Page 8 of the interface schematic (Appendix A).

The two long messages players are started with an output command, stop automatically and send off an interrupt upon stopping. The start and automatic stop mechanism of the Sony players is mechanical. The player, without modification, starts upon insertion of a cartridge and stops when a metallic strip on the tape shorts two contacts. To restart the player after an automatic stop, the cartridge must be reinserted. Insertion causes movement of a lever which turn the player on. The player was modified so a solenoid could control the lever operation and so that the tape could be permanently inserted. Automatic stop is enabled when a metallic strip on the tape shorts a 20 volt lead on the tape head to ground. This same signal is used to send an interrupt to the computer.

The logic control circuit is on Page 8 of the interface diagram. An output command sets either FF6 or FF7. This in turn turns the solenoid on and thus the tape player. The shorting of the tape to ground sends off an interrupt (see Page 7). N1 and N2 are used to eliminate interrupts caused by contact bounce between the metallic strip and the sensing heads. If FF6 and FF7 is set, it will be immediately cleared by the first contact pulse. This clearing prevents extra interrupts from getting through N1 and N2.

The Solenoids require 30 volts DC for operation (see Page 10). A power supply was designed and built to produce 30 volts DC at 1 ampere. A triad F92-A transformer reduced 117 volts AC to 30 volts AC. A simple filter network composed of a 1N2071 diode bridge, a one ohm resistor and a Sprague 40 VAC 5500 uf capacitor converted the AC to 30 volts DC with ripple of less than .5 volts.

The output of the tape recorder was only .5VRMS. Proper output voltage for adequate volume at the telephone earpiece is around 4 volts RMS. An amplifier was built to produce this amplification (see Page 9). Input to this amplifier was through three variable resistors, volume controls, to compensate for variations in recording levels on the tapes and to reduce the amount of input from one tape recorder that fed to ground through the inputs of the other tape recorders. The output from the amplifier was then fed to a common collector amplifier that increased the output impedance to 5600 ohms. This increase was necessary because

the output impedance insures that most of the audio-response output feeds to the telephone and not to ground through the tape recorder amplifiers.

#### Test Program

A test program has been written to assist in maintenance of the equipment and interface. The program tape is loaded into the Interdata 3 in the normal manner using the relative loader. The user then uses the teletype to input a number indicating the test he wishes to perform. The tests and the input number are listed below. The program is listed in Appendix B.

<u>Number</u>	<u>Test</u>
1	Plays back the ARU tracks in order.
2	Enables one digit input. The user then presses a touch-tone button and will hear that number played back.
3	Enables two digit input. The user then presses two touch-tone button sequentially, and will hear the two numbers repeated.
4	Starts and plays tape player one.
5	Starts and plays tape player two.
6	Starts and plays the music player.
7	Enables answering of the telephone.
8	Stops the music player.

Maintenance of the equipment described above should be minimal as reliability and long life were two of the design criteria.

With both the Cognitronics unit and the tape recorders, the required maintenance is described in the literature sent with the devices. Serious problems with Cognitronics

unit should be referred to:

Cognitronics, Inc.  
Mt. Kisco, New York

The tape players can be repaired at any electronics repair shop. The modifications made for this thesis should not interfere with their repair.

The telephone data set will be repaired by the telephone company. Dial telephone repair service (611) and they will send a repairman within the hour.

USE OF THE SYSTEM IN LIBRARY CIRCULATION CONTROL

The hardware design allows the use of this system in many user interactive applications even though the application for which this system was designed is a library user information system. In order to demonstrate the sufficiency of the hardware for this specific application a prototype software system has been constructed and successfully demonstrated. The program is listed in Appendix C and described below.

The Interdata in the library project is designed to act as a communications control center switching data between time-sharing and various peripheral units. A program running under time-sharing will handle all library file manipulations. This approach allows simplification of Interdata programming, and conserves space in the small (8 K bytes) Interdata core memory. A program is being written<sup>24</sup> for the ID-3 to handle interrupts and communication with time-sharing. The ID-3 subroutines necessary to control the user information system have to interface with this program, and have to be as short as possible.

The main program handles interrupts, determines the interrupting machine and branches to the routine handling that machine. When one of the six devices in the user information system sends off an interrupt the main program branches to ARSTAT, the ID-3 library user system routine executive. This executive examines the status byte and branches to the subroutine for handling that particular

device. A decreasing priority search is made to determine the device interrupting. This is necessary in case two devices interrupt at the same time, for example, hang up and the ARU. Hangup has the higher priority and the ARU interrupt is ignored. Logically this is the correct programming format. If a person hangs up in the middle of a transaction, the program should immediately terminate processing on that call, and initialize variables for the next incoming call.

Program priority in the prototype is in decreasing order, as follows:

1. Hangup
2. Data Set Data
3. Data Set Ready
4. ARU Interrupt
5. Tape Recorder 1
6. Tape Recorder 2

This priority is under software control, and can be easily modified.

The hangup (HANGUP) subroutine disables ARU interrupt and data input. The data set ready (DSRDY) subroutine starts tape recorder number one, the introduction message. The tape recorder one finished subroutine (INTRO) sets a yes-no input flag and enables one number input. The Introduction recorded on tape recorder one asks the user to input a one if he desires instructions and zero if not. The tape recorder two finished subroutine (INST) enables data input and

enables two number input. This sets up the system to receive the book number, the user identification number and a service request type.

The data set data (DSDATA) subroutine first disables data input. If the yes-no flag is set it branches to a subroutine to either start tape recorder number two or enable data input. If the yes-no flag is not set, the subroutine reads the data, checks for error or end of message input, and if neither of these are present converts the data to ASCII, and a track address. The ASCII is stored in an output buffer. The end of message input causes a branch to a subroutine to start music and transmit the data to time-sharing. The error input erases the last letter from the output buffer.

In the prototype system, after each alphanumeric character is input, the system plays back that letter for the user's verification. If there is an error the user can correct it using the error input "40", followed by the correct code. In order to play back an alphanumeric character to the user, the computer must disable data input. This connects the audio-response output to the telephone line. The audio-response unit is then enabled, and the character written to the interface. The program then waits for two audio-response unit interrupts before enabling data. The first interrupt indicates start of audio output and the second interrupt indicates completion of the task. ARFLG1 is the counter, and ARGLG2 indicates to the audio-response routine that a track is to be played.

The audio-response subroutine (ARUINT) first checks for ARFLG2. If set the program branches to a subroutine to count two ARU interrupts and then enable 2 digit data input and disable the ARU. The only other possible entrance to ARUINT is during the outputting of a message. If the end of list flag is set (DACN1) the long message output is complete and the program disables the ARU, and enables 2 digit data input. If not, the program branches to GWRITE a routine in the main program that writes the next item of data from a buffer to the correct device, in this case the ARU.

This program was written to conserve core memory, and yet enable ease of operation of the system by the users.

The user interacts with the system as described below:

1. User dials library information number.
2. User hears 2 to 5 second tone, followed by the following message: "Hello, this is user information service of the Baker Library at Dartmouth College. If you would like information on how to use this system, press the one button on your telephone at the end of this message. If not, press the zero button and input the required information. Thank you."
3. User presses a one or zero. If the user inputs a one, he will hear the instructions as shown in step 4. If he inputs a zero, he jumps to step 5.
4. The instructions the user will hear are written below.  
"The computerized library information service of Baker Library at Dartmouth College will provide you

with various services and information for any book listed in the card catalog. The information available is whether the book is in, out, or has been lost. If the book is in the library, the stack location is provided. If the book is out, the borrower identification number, and the due date are provided. This system also offers you the services of placing or releasing a hold on a book, or renewing a book you have borrowed."

"Data is input to the system by pressing the ten buttons on your touch-tone telephone in a specially coded sequence. This special code is as follows, and perhaps you should write it down. Letters are represented by the digit sequence 0-1 to 2-6. For example, A is a zero followed by a 1 while an M is a 1 followed by a 3. Numbers are three followed by the digit. The decimal point is 4-0, the end of message is 5-0, and the error indicator is a 6-0."

"You input the following sequence of data. First you key in your user identification number. Next comes the book number, and then a service request code and the end of message code."

"The service request code designates to the system the type of service you desire. An I means information, an H means you wish to place a hold, a G means you wish to release a hold, and an R means you wish to renew a book you already have out."

"After you input two digits, wait until you hear a reply from the system verifying the character you input. If this returned character does not agree with the one you meant to input simply indicate an error by the error code 6-0, and then input your new character."

"After supplying the end of message code, you will have approximately a 20 second wait before you will hear a reply."

"Thank you."

5. The user inputs his identification number and the identification number of the book he is interested in, a character at a time. The system will echo through the audio-response unit, the number or character the system thought was input. If the character is wrong, the user inputs a 40 to delete the character.
6. The user inputs a service request code and an end of message code...

R means the user would like to renew a book.

H means the user would like to place a hold on a book.

I means the user would like information on the book.

G means the user would like to release his hold on the book.

The user then hears music for 20 to 30 seconds.

7. The system outputs a message through the audio-response unit regarding the service requested or the information desired.

Possible message variations are listed below:

<u>Service Type</u>	<u>Message</u>
I	Book is in stack number (X).
I	Book is lost.
I	Book is out. Borrower (user I.D. number). Due Date ( <u>month</u> , <u>day</u> , <u>year</u> ).
H	Return book. A hold has been placed.
R	Due date (month, day, year).
H	A hold has been placed.
G	A hold has been released.

8. The user can now input a "70" indicating he would like to hear the message repeated, or input a new book number, or hang-up, thus indicating completion of his interaction with the system.

This prototype system has been constructed and demonstrated successfully. Input of data is easy and rapid, and the responses are clear. Other applications can use the basic hardware. New long messages can be recorded on the cartridge tapes, and a different vocabulary can be recorded by Cognitronics onto a new film, and then easily attached to the ARU.

## CONCLUSIONS AND RECOMMENDATIONS

The library user information system as designed and constructed is an improvement over the status quo. It has been built and demonstrated; thus it is technically feasible. It conserves both librarian and user effort, and it has been economically justified.

However, as is usual, this system is not optimum, and there are several improvements that will reduce cost, improve reliability, and improve the system.

The three tape recorders used in the system are all eight track stereo with separate preamps. Since all three tape recorders go to one output they could use the same preamplifier. Also, only one track is used per tape player. A tape player with one track monaural output would be less expensive. The two Sony tape players use mechanical means to automatically stop the player at the end of the tape. Perhaps electronic methods would reduce cost, and improve the reliability.

If many copies of the interface were to be built the use of printed circuits cards for the interface would reduce assembly and testing time, and thus reduce cost. The integrated circuits are available in quantities at a reduced price.

The data set is a half duplex data set. It can receive data or send voice, but not both. This creates several problems. A user must hear an entire tape loop even if he has

heard all he needs to know. Also, in order to play back from the ARU the alphanumeric input, the program must disable data input, write a track address to the ARU and wait two ARU interrupts before data can be again enabled. This causes a slight degradation in system response speed, and an impatient user can "beat" the computer by inputting data before the system is ready. Full duplex would reduce programming requirements, and improve system response speed.

One other data set related problem is delivery delay. The data set used in this system was ordered from the Bell System on November 15, 1968. It was installed June 6, 1969.

The Interdata computer is a medium speed, low reliability computer. Since ordered the computer used in this system has been down very often, and tends to fail at crucial moments. The twenty-four hour repair service advertised by Interdata is more often a 48 to 96 hours repair service.

The small size of the Interdata core memory keeps the total system cost down, but limits the library user information system in services available. The demonstration program as written uses ten percent of core memory. The ability to repeat the last alphanumeric character or to repeat the book number as input at the time of the request are additional services that could be added at more used memory. The problems in increasing system services are not hardware limited, but are core limited.

The music player used in the system can use any music. Perhaps playing electronic music would convince the user that he can hear the computer working. The "music" could

even be a recorded message that repeats "Just a second please" every ten seconds. Also, a completely transistorized tape player would allow immediate music output with no warmup time, and would prevent the dying music sound heard when the player is turned off.

Perhaps a future system could use a slightly more sophisticated ARU with word/phrase capability. This would allow a broader range of responses, and would produce more natural sounding speech by combining words and phrases. However, this would also require more program in the Interdata and additional interface circuitry.

In the section "Economic Analysis", three systems were presented. The second system used a teletype located in the library. Further economic analysis reveals that the rental price of the teletype could be reduced to \$17 per month, and the ARU system would still result in saving each year for ten years to produce a six percent return on the initial investment.

Perhaps the greatest problem with the entire library project is the one 110 baud line to timesharing. Several devices requesting time-sharing interaction would produce large delays. A high speed line would only improve transmission speed, but not timesharing speed. Two or more 110 baud lines to timesharing would take better advantage of the speed of the Interdata computer, and the timesharing of the GE-635.

Touch tone service will not be available in Hanover

until January 1971. A dial pulse converter to translate dial pulses into data could be used in the interim. This could be installed by inductively picking up the dial pulses from the incoming telephone line (it cannot be done after the data set because of the half duplex nature of the data set). However, the total library system is not yet complete, and probably will not be installed in Baker Library until well after January 1971, thus making a dial pulse converter unnecessary.

It is the recommendation of this report that the library user information system as described in this report be installed with the automated library circulation system.

BIBLIOGRAPHY

1. J.S. Craven, "A review of electro mechanical mass storage," Datamation, pp.22-28, July 1966
2. M.R. Schroeder, "Vocoders, Analysis and Synthesis of Speech," Proc. IEEE, 54,720-34 (1966).
3. "Digital to Voice Conversion," IEEE International Convention Record, Part I, 1965.
4. H. Dudley, "Remaking Speech," Journal of the Acoustical Society of America, 11 (2); 169-177, 1939.
5. "Phase Vocoder," Vol. 45 (1966), p.1493-1498, Bell Systems Technical Journal.
6. L.F. Melick, "The computer talks back," Data Processing Mag., October 1966; 58-62.
7. M.H. Levin, "Portable Electronic Keyboard for Computer Input By Telephone; IEEE Trans. Elec. Comp. Vol. 16; No. 3, June 1967, 332-334.
8. Leon Davidson, "Poor Man's time shared computer input: The Button Telephone," Computers and Automation; Feb. 1965
9. A.B. Urguhart, "Voice Output from IBM 360," In. Proc. AFIPS 1965, Fall Joint Computer Conference, Pt 1, 857-865.
10. I.R. Neilson, "A Simple Data Transmission System Using the Office Telephone," Comm. ACM 8; 10 (October 1965) 634-635.
11. "Audio Response in Banking," Datamation 11, 7 (June 1965) 34-38.
12. "Better Vocoders are Coming," IEEE Spectrum 1, 9 (Sept. 1964), 119-129.
13. "Converting Digital Data to Voice," Electronics Industries 23, 4 (April 1964) 84-86.
14. "Shoebox - A Voice Response Machine," Datamation 8, 6 (June 1962) 47-50.
15. "A Method of Voice Communication with a Digital Computer," Proc. Eastern Joint Computer Conference, 18, December 13-15, 1960; 11-24.

BIBLIOGRAPHY (continued)

16. A.J. Prestigaeome, "Voice Excited Vocoder For Practical Speed Bandwidth Reduction," IRE Trans. IT-8, 5 (September 1962) 101-105.
17. F.H. Rothhauser, "The Integrated Vocoder and Its Application in Computer Systems," IBM Journal, November 1966, 455-461.
18. "Speech - Man's Natural Communication," IEEE Spectrum, June 1967, 75-86.
19. "Library Reference Manual," Baker Library at Dartmouth College, 1969.
20. "Interface Specifications - X403A2 Data Set," Bell Telephone Company, 1967.
21. "Reference Manual," Interdata, Inc., 1967.
22. "Interface Specifications," Interdata, Inc., 1967.
23. Garwood E. Erickson, "Computerized Audio-Response Library User Information System," B.E. Thesis, Dartmouth College, June 1968.
24. "Automated On-Line Real-Time Library Circulation System," Thomas F. Piatkowski, October 1968.

APPENDIX A

NOTATIONAL SYSTEMInterface Board  
Integrated Circuit Placement

There are five sub-circuit boards contained on the main circuit board. These are labeled in the lower right hand corner with a letter from A to E. Schematic pages following refer to one of these five boards.

On each board there are from four to twelve integrated circuit packages. The uppermost number in each package refers to the Motorola integrated circuit designation. For example, on board A, the number 857 refers to Motorola package MC857. There is one exception to this. There is on board C a Fairchild integrated circuit package. This is listed as F9311. The lower number on each package is the integrated circuit package number.

## Schematic notation

Each page refers to one of five boards, and the gates on each page refer to the integrated circuit package number for that board. The numbers immediately adjacent to each gate on the lines leading into and away from each gate are the integrated circuit pin numbers.

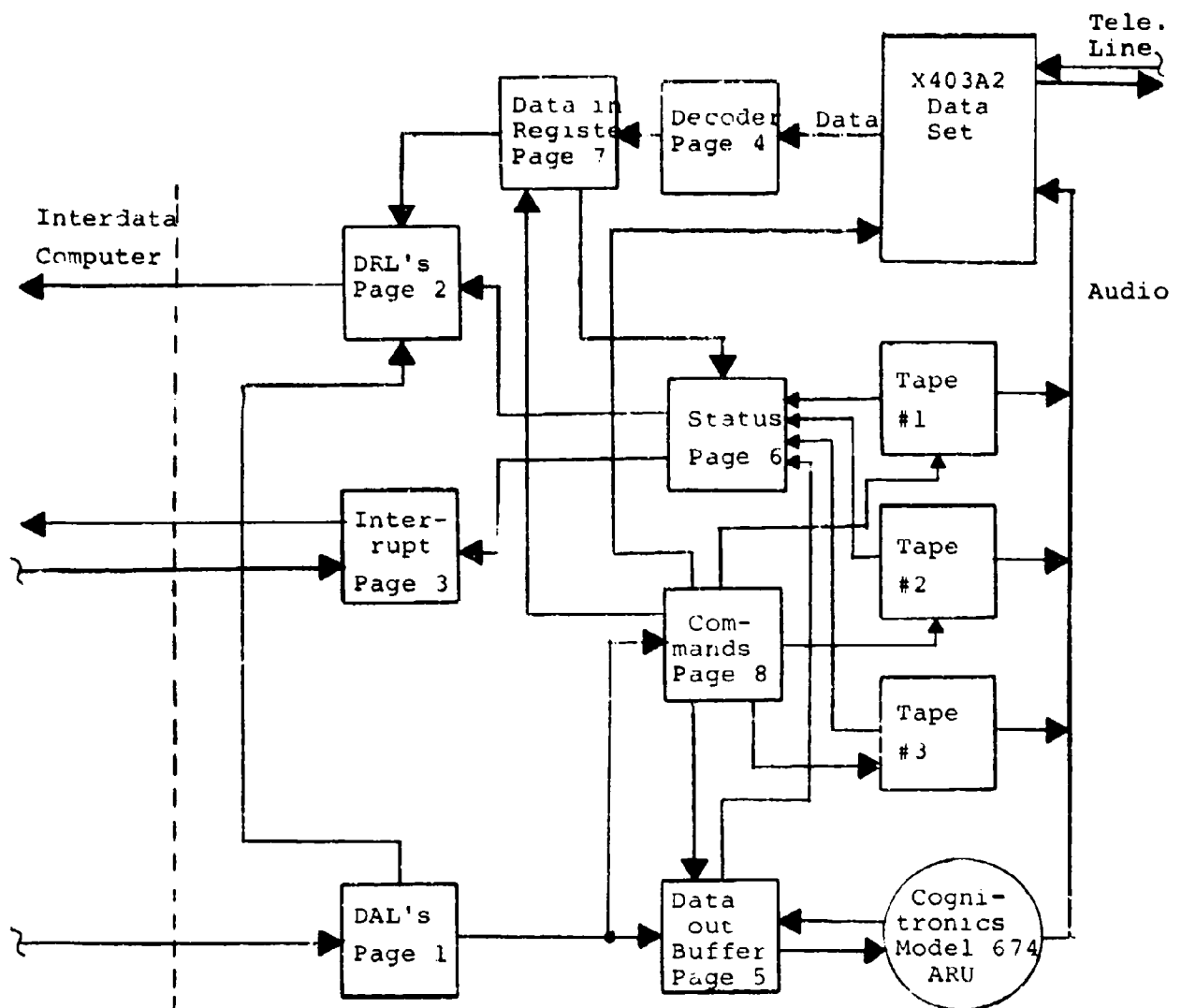


## Interface Board

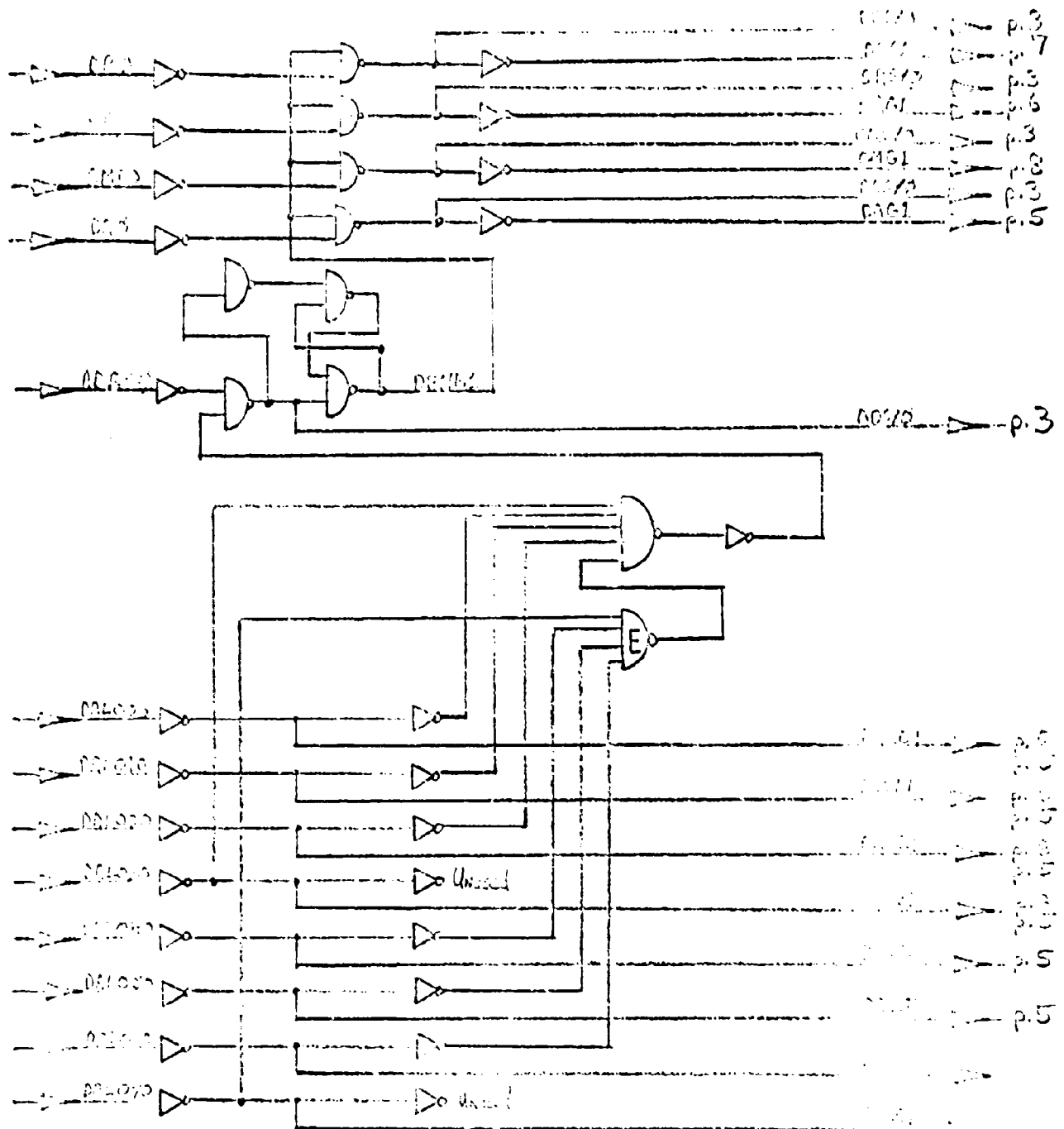
## Integrated Circuit Placement

## INTERFACE SCHEMATIC

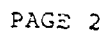
## OVERVIEW



A-4  
ADDRESSING

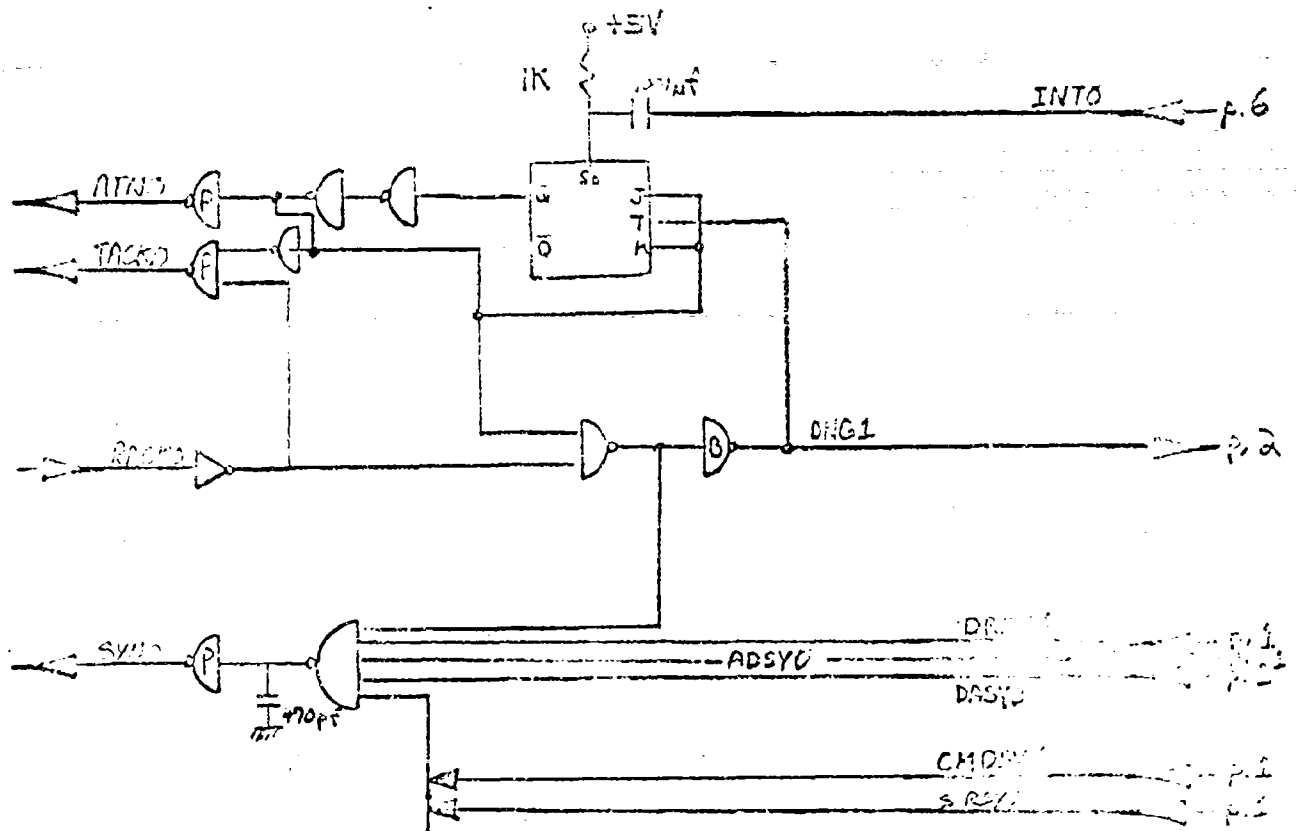


DRL'S



A-6

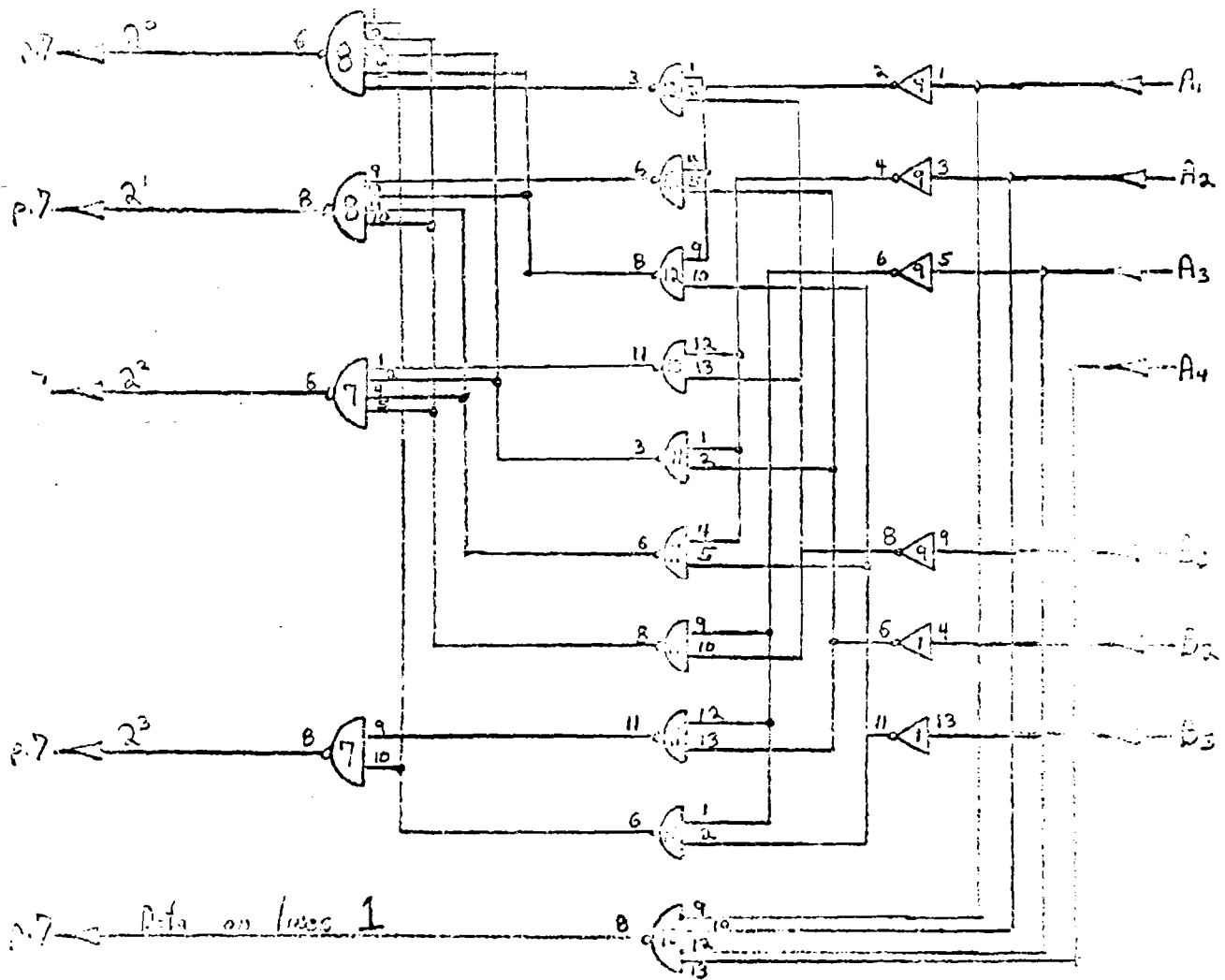
INTERRUPT



A-7

DATA DECODER

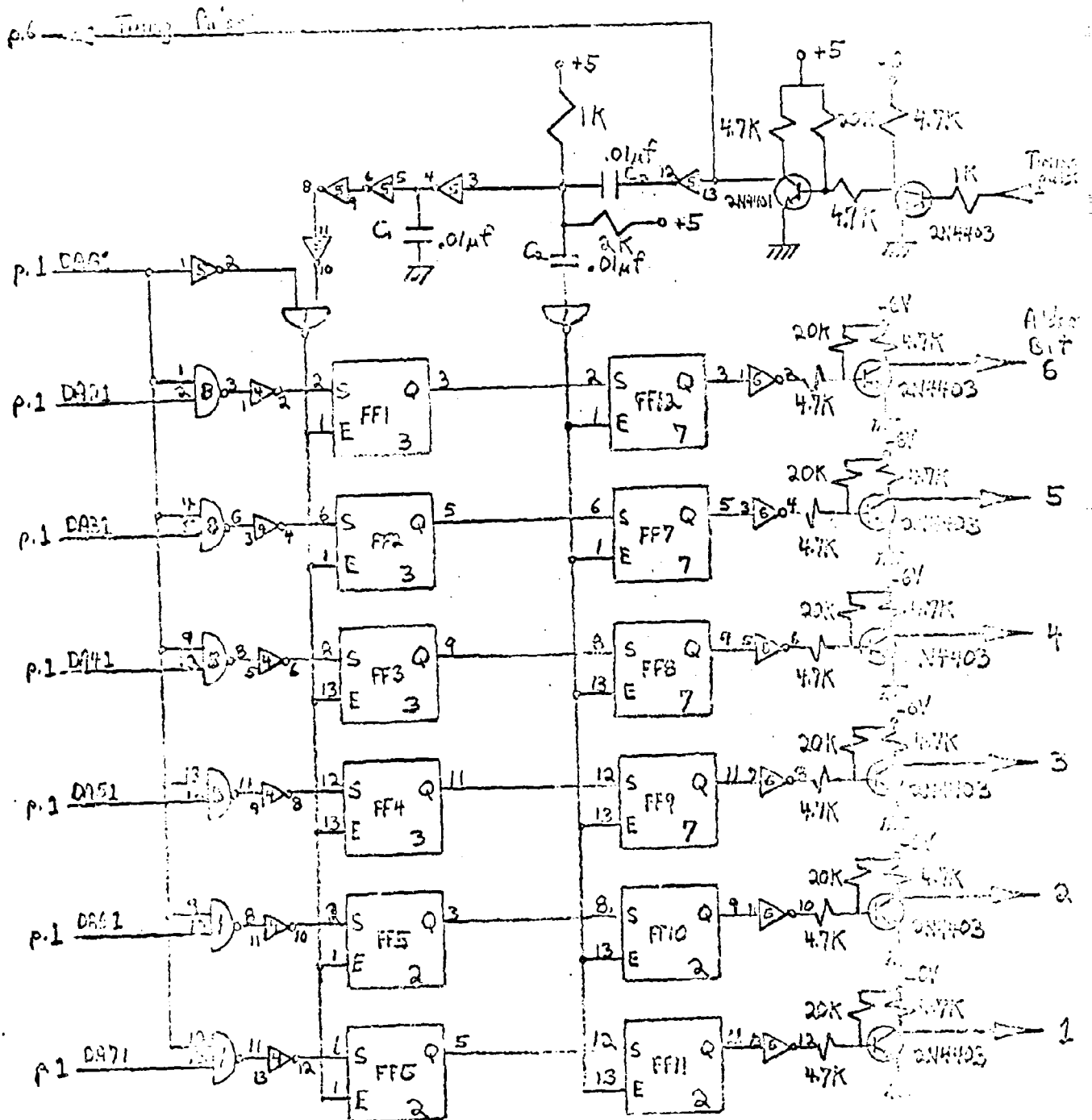
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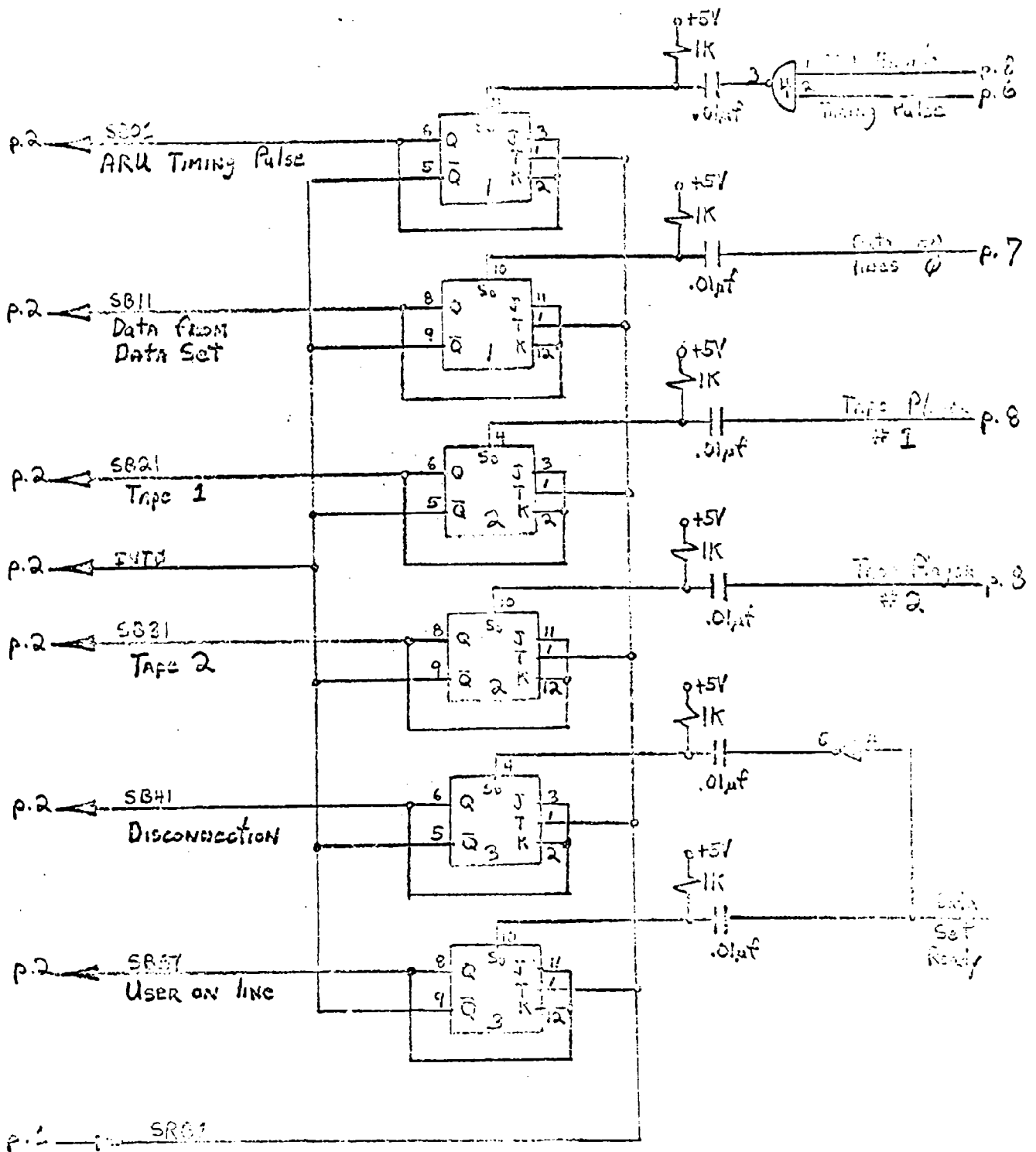
A-8

NOT REPRODUCIBLE

DATA TO ARU



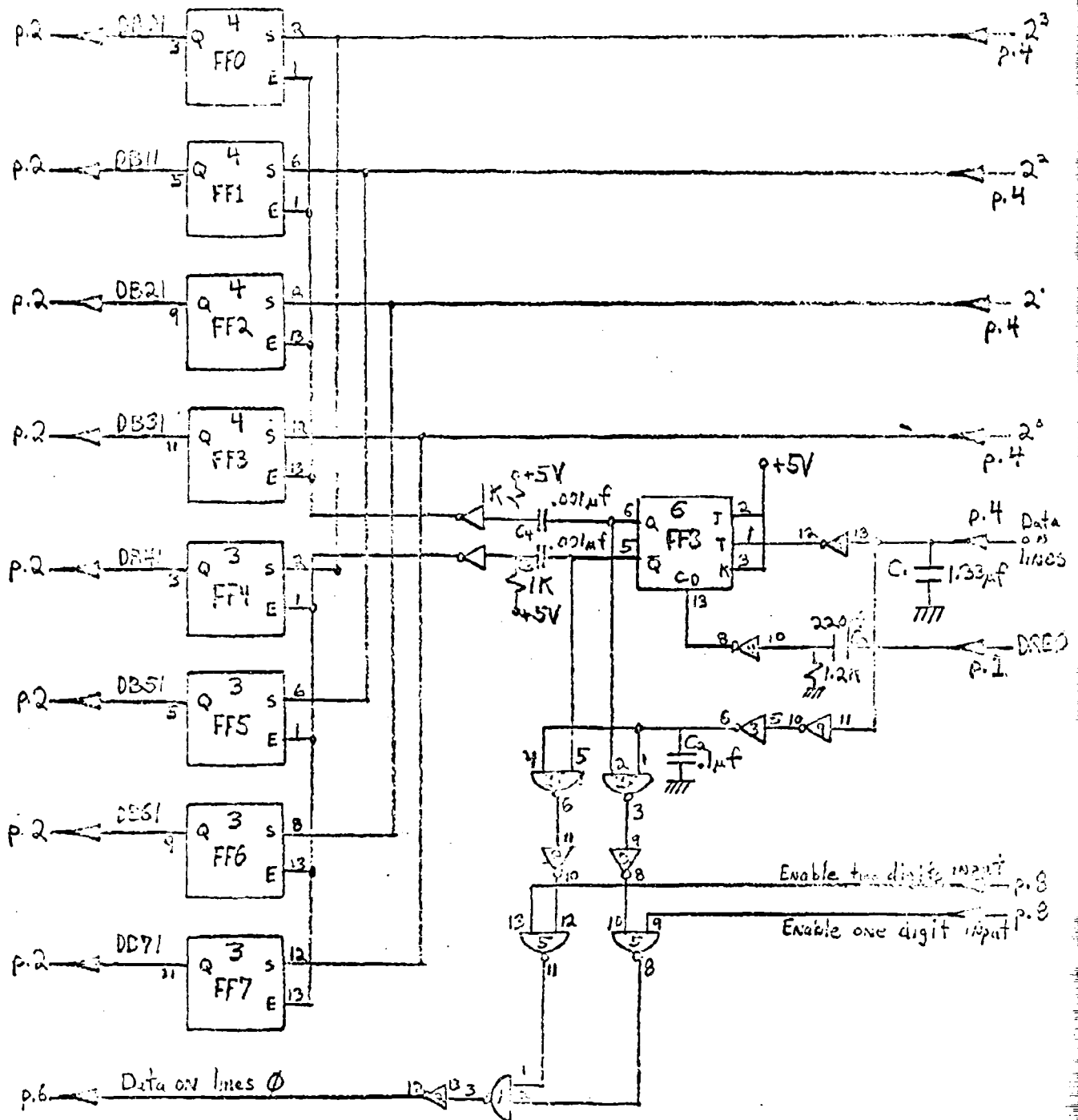
## STATUS REGISTER



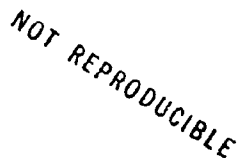
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# DATA REGISTER

NOT REPRODUCIBLE

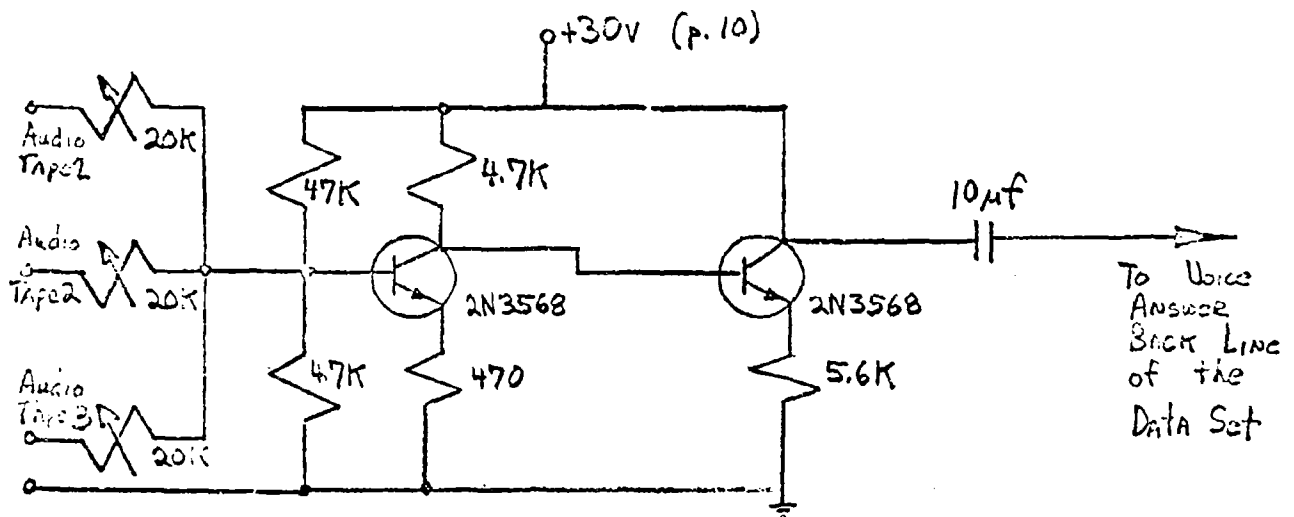


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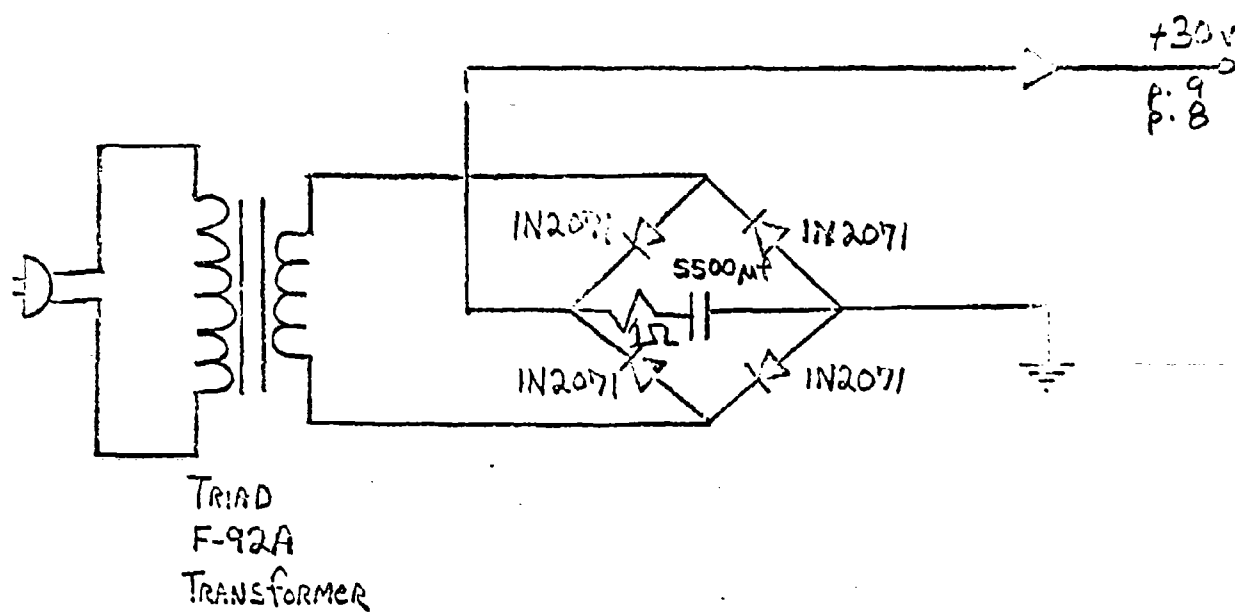
A-12

AUDIO AMPLIFIER



Amplifier: Max input 1.4v peak to peak  
Max output 12v peak to peak

## POWER SUPPLY



APPENDIX B

B-1  
ARU TEST PROGRAM

			OPT	PASS2, PRINT, PUNCH, STOP
1400			ORG	X'1400'
1400	C840	EXEC	LHI	4,X'2' TTY
	0002			
1404	C850		LHI	5,X'11' ARU
	0011			
1408	C860		LHI	6,X'0000'
	0000			
140C	4060		STH	6,X'40'
	0040			
1410	C860		LHI	6, TTY
	141C			
1414	4060		STH	6,X'42'
	0042			
1418	C200		LPSW	X'40'
	0040			
141C	2000	TTY	SSR	4,6
141E	C560		CLHI	6,X'0'
	0000			
1422	4230		BNE	TTY
	141C			
1426	9B46		WDR	4,6
1428	C870		LHI	7,X'80'
	0080			
142C	9A47		WDR	4,7
142E	9D47	TTY1	SSR	4,7
1430	C570		CLHI	7,X'10'
	0010			
1434	4230		BNE	TTY1
	142E			
1438	C870		LHI	7,X'8A'
	008A			
143C	9A47		WDR	4,7
143E	C560		CLHI	6,X'B1'
	00B1			
1442	4330		BE	ARU
	1482			
1446	C560		CLHI	6,X'B2'
	00B2			
144A	4330		BE	NUMB1
	14B8			
144E	C560		CLHI	6,X'33'
	0033			
1452	4330		BE	NUMB2
	150A			
1456	C560		CLHI	6,X'B4'
	00B4			
145A	4330		BE	TAPE1
	1584			
145E	C560		CLHI	6,X'B5'
	00B5			
1462	4330		BE	TAPE2
	1598			
1466	C560		CLHI	6,X'36'

## B-2

146A	0036 4330 1506		BE	MUSIC
146E	0560 00B7		CLHI	6,X'B7'
1472	4330 1500		BE	ANSWER
147C	0560 00B8		CLHI	6,X'B8'
147A	4330 1506		BE	STOP
147E	4300 141C		B	TTY
1482	C860 0003	ARU	LHI	6,3
1486	9E56		OCR	5,6
1488	C860 000A		LHI	6,X'A'
148C	9E56		OCR	5,6
148E	C870 0000		LHI	7,0
1492	9D56	ARU1	SSR	5,6
1494	C460 0080		NHI	6,X'80'
1498	4330 1492		BZ	ARU1
149C	CA70 0001		AHI	7,1
14A0	C570 0040		CLHI	7,X'40'
14A4	4330 14AF		BE	ARU2
14A8	9A57		WDR	5,7
14AA	4300 1492		B	ARU1
14AE	C860 000B	ARU2	LHI	6,X'B'
14B2	9E56		OCR	5,6
14B4	4300 141C		B	TTY
14B8	C860 0002	NUMB1	LHI	6,X'2'
14BC	9E56		OCR	5,6
14BE	C860 000C		LHI	6,X'C'
14C2	9E56		OCR	5,6
14C4	9D56	NUMB11	SSR	5,6
14C6	C460 0040		NHI	6,X'40'
14CA	4330 14C4		BZ	NUMB11
14CF	9B57		RDR	5,7
14D0	C860 0003		LHI	6,3

## B-3

14D4	9E56		OCR	5,6
14D6	C860		LHI	6,X'A'
	000A			
14DA	9E56		OCR	5,6
14DC	CC70		SRHL	7,4
	0004			
14EO	CA70		AHI	7,H'30'
	001E			
14E4	9A57		WDR	5,7
14E6	C880		LHI	8,0
	0000			
14FA	9D56	NUMB12	SSR	5,6
14EC	C460		NHI	6,X'80'
	0080			
14FO	4330		BZ	NUMB12
	14FA			
14F4	CA80		AHI	8,1
	0001			
14F8	C580		CLHI	8,3
	0003			
14FC	4230		BNE	NUMB12
	14EA			
1500	C860		LHI	6,X'B'
	0008			
1504	9E56		OCR	5,6
1506	4300		B	TTY
	141C			
150A	C860	NUMB2	LHI	6,2
	0002			
150E	9E56		OCR	5,6
1510	C860		LHI	6,4
	0004			
1514	9E56		OCR	5,6
1516	9D56	NUMB21	SSR	5,6
1518	C460		NHI	6,X'40'
	0040			
151C	4330		BZ	NUMB21
	1516			
1520	9A57		RDR	5,7
1522	C860		LHI	6,3
	0003			
1526	9E56		OCR	5,6
1528	C860		LHI	6,X'A'
	000A			
152C	9E56		OCR	5,6
152E	0R97		LHR	9,7
1530	CA70		NHI	7,X'F0'
	00F0			
1534	CC70		SRHL	7,4
	0004			
1538	CA70		AHI	7,H'30'
	001E			
153C	9A57		WDR	5,7
153E	C880		LHI	8,0

## B-4

	0000			
1542	9D56	NUMB22	SSR	5.6
1544	C460		NHI	6,X'80'
	0080			
1548	4330		BZ	NUMB22
	1542			
154C	C460		AHI	8.1
	0001			
1550	C580		CLHI	8.2
	0002			
1554	4230		BVE	NUMB22
	1542			
1558	C490		VHI	9,X'F'
	000F			
155C	C490		AHI	9,H'30'
	001E			
1560	9A59		WDR	5.9
1562	C880		LHI	8.0
	0000			
1566	4300		B	NUMB12
	14FA			
156A	C860	TAPE1A	LHI	6,X'A'
	000A			
156E	9F56		OCR	5.6
1570	4860		LH	6,TAPE
	15D6			
1574	9F56		OCR	5.6
1576	9D56	TAPE11	SSR	5.6
1578	4		NH	6,INTER
	15D8			
157C	4330		BZ	TAPE11
	1571			
1580	4300		B	TTY
	151C			
1584	C860	TAPE1	LHI	6,X'5'
	0005			
1588	4060		STH	6,TAPE
	15D6			
158C	C860		LHI	6,X'20'
	0020			
1590	4060		STH	6,INTER
	15D8			
1594	4300		B	TAPE1A
	156A			
1598	C860	TAPE2	LHI	6,X'D'
	000D			
159C	4060		STH	6,TAPE
	15D6			
15A0	C860		LHI	6,X'10'
	0010			
15A4	4060		STH	6,INTER
	15D8			
15A8	4300		B	TAPE1A
	156A			

B-5

15AC	C860	ANSWER	LHI	6,X'E'
	000E			
15AD	9E56		OCR	5,6
15B2	4300		B	TTY
	141C			
15B6	C860	MUSIC	LHI	6,X'1'
	0001			
15BA	9E56		OCR	5,6
15BC	C860		LHI	6,X'A'
	000A			
15C0	9E56		OCR	5,6
15C2	4300		B	TTY
	141C			
15C6	C860	STOP	LHI	6,X'2'
	0002			
15CA	9E56		OCR	5,6
15CC	C860		LHI	6,X'9'
	0009			
15D0	9E56		OCR	5,6
15D2	4300		B	TTY
	141C			
15D6		TAPE	DS	1
15D8		INTER	DS	1
15DA			END	EXEC

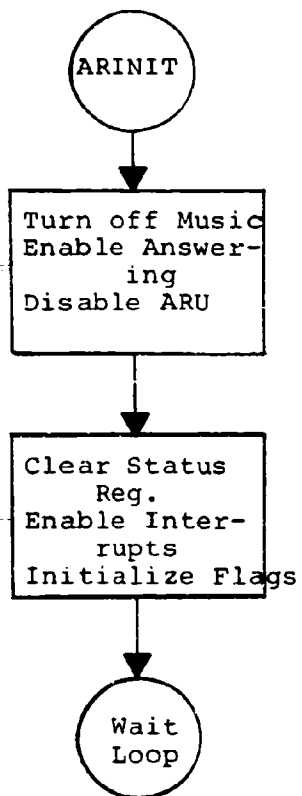
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ARU	1482
ARU1	1492
ARU2	14AE
EXEC	1400
INTER	15D8
MUSIC	15B6
NUMB1	1488
NUMB11	14C4
NUMB12	14EA
NUMB2	150A
NUMB21	1516
NUMB22	1542
STOP	15C6
TAPE	15D6
TAPE1	1584
TAPE11	1576
TAPE1A	156A
TAPE2	1598
TTY	141C
TTY1	142E

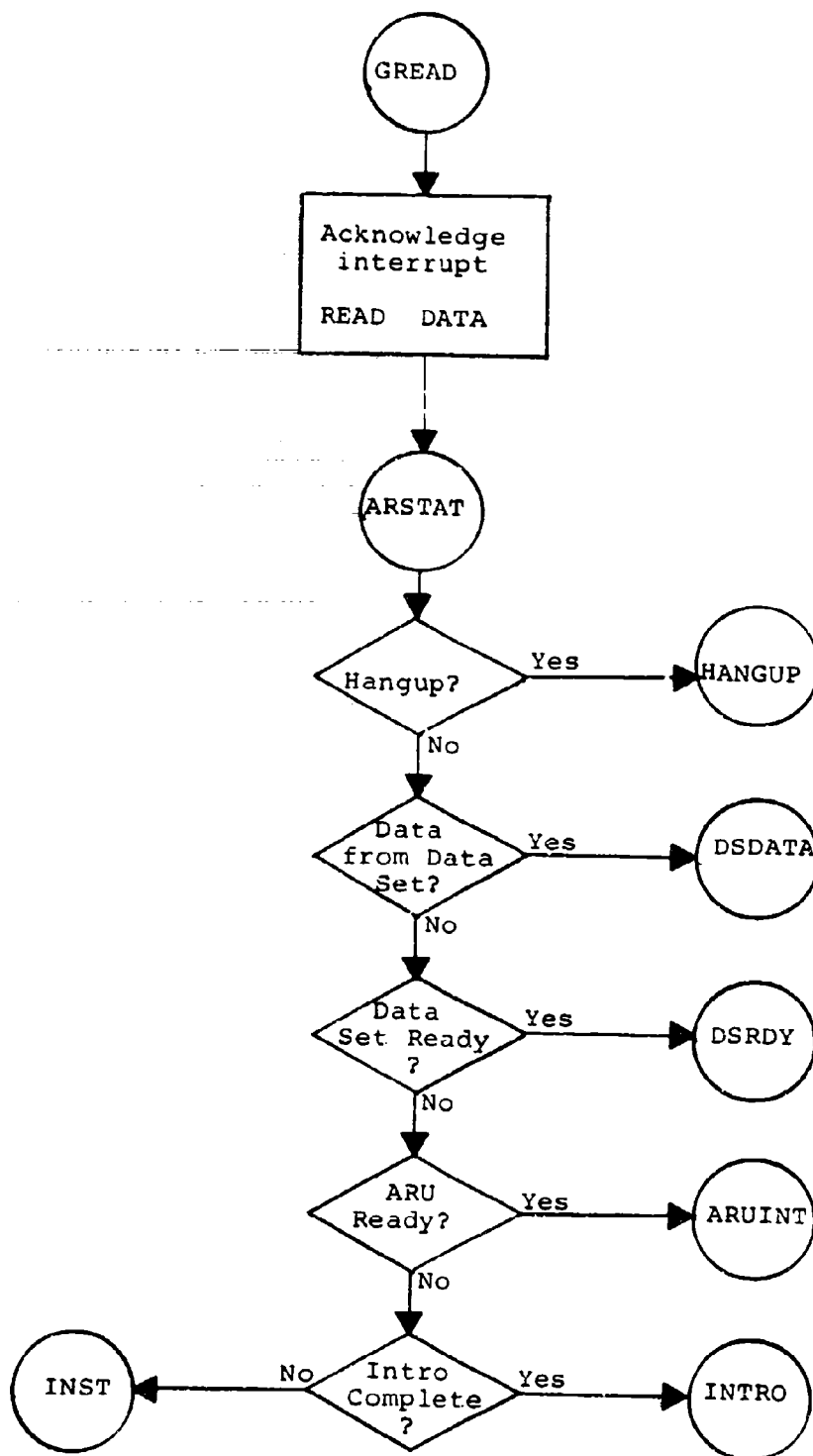
APPENDIX C

C-1

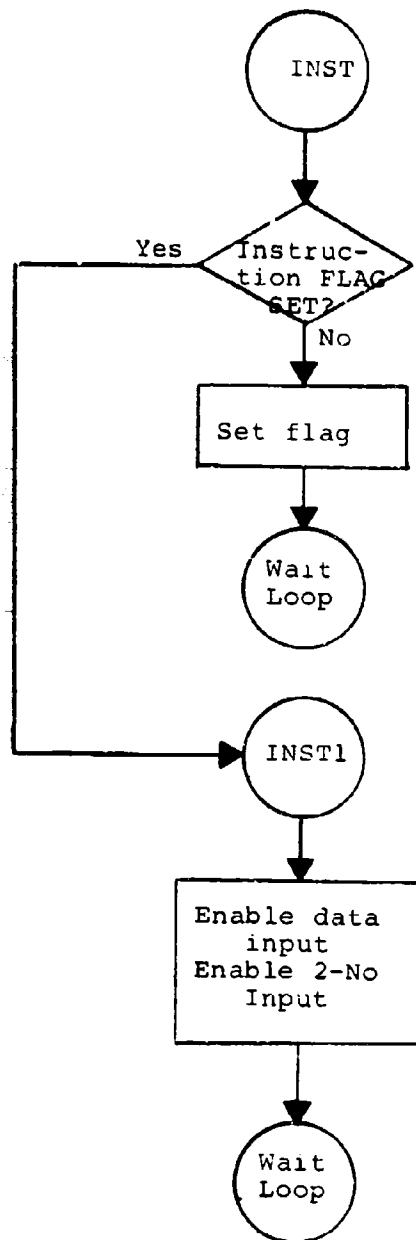
ARU System Demo Program

Flow Chart

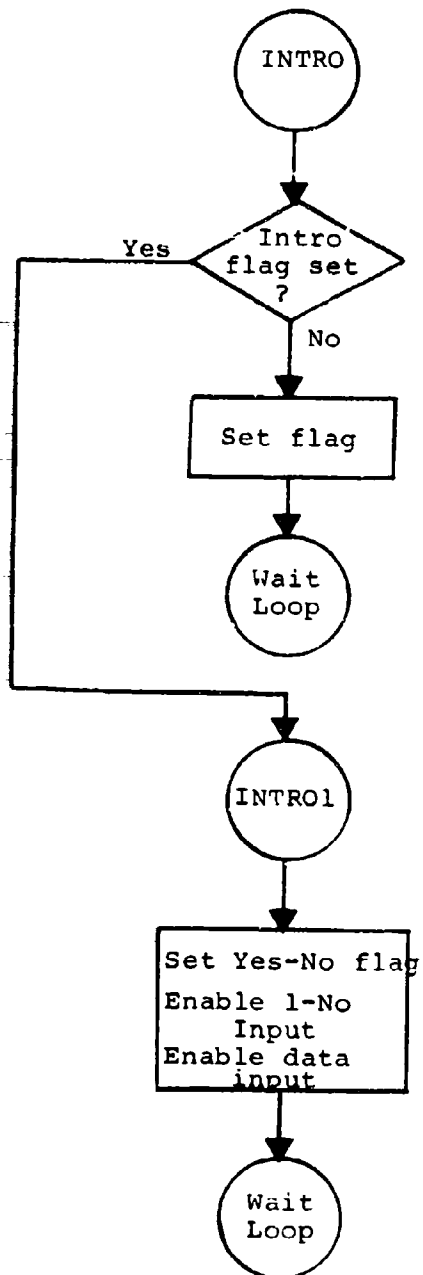




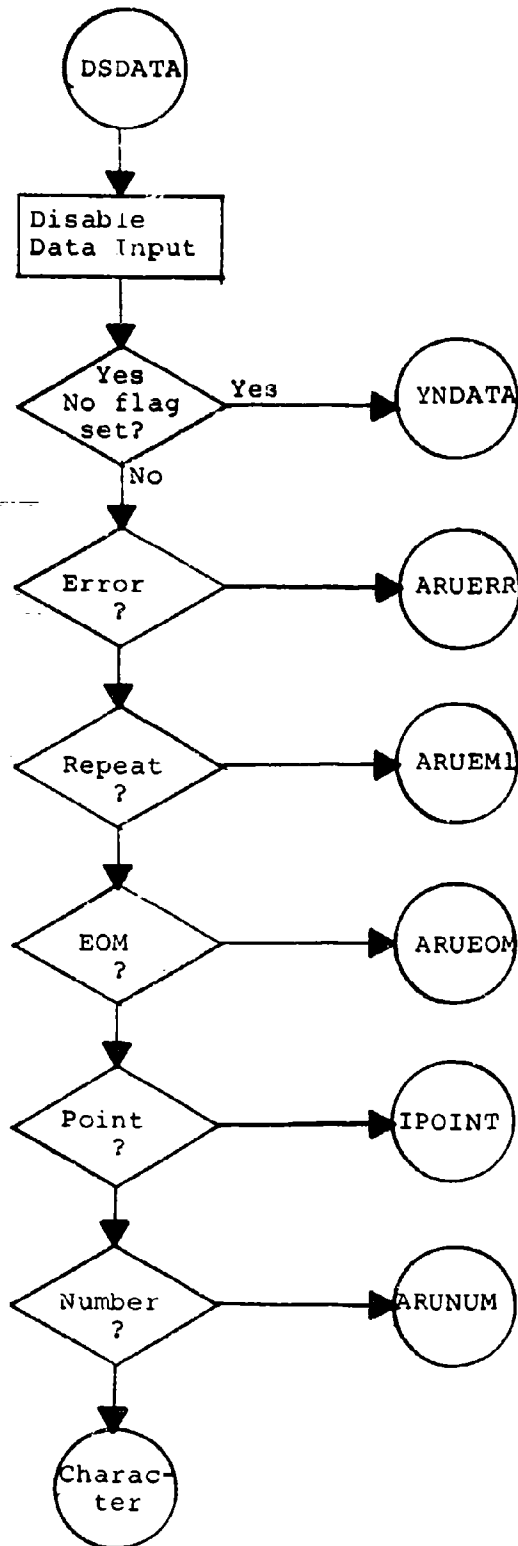
C-3

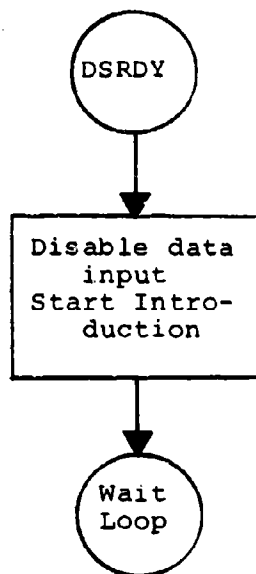
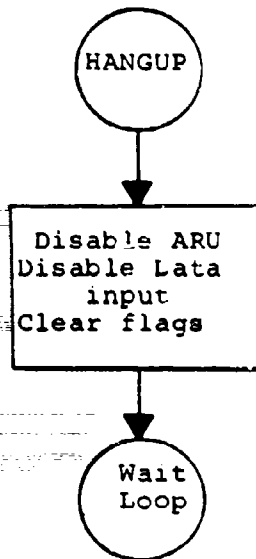


C-4



C-5





C-7  
LIBRARY USER INFORMATION SYSTEM  
DEMONSTATION PROGRAM

		OPT	PASS, PRINT, PUNCH, STOP	
1000		ORG	X'1000'	
1000	0850	ARINIT LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011			
1004	0860	LHI	6,X'9'	TURN OFF MUSIC
	0009			
1008	0860	OCR	5,6	
100A	0860	LHI	6,X'E'	ENABLE ANSWERING
	000E			
100E	9E56	OCR	5,6	
1010	0860	LHI	6,X'B'	DISABLE ARU
	000B			
1014	9E56	OCR	5,6	
1016	9D56	SSR	5,6	CLEAR THE STATUS REGISTR
1018	0860	LHI	6,X'1'	LOAD 1 INTO R6
	0001			
101C	4060	STH	6,DACN1	SET END OF LIST MASK
	1324			
1020	08A6	LHR	10,6	SET END OF LIST FLAG
1022	0850	LHI	5,X'4000'	ENABLE INTERRUPTS
	4000			
1026	4050	STH	5,X'40'	
	0040			
102A	0850	LHI	5,IEXIT1	LOAD WAIT LOOP ADDRESS
	1056			
102E	4050	STH	5,X'42'	
	0042			
1032	0850	LHI	5,X'0'	
	0000			
1036	4050	STH	5,X'44'	
	0044			
103A	4050	STH	5,YNFLAG	
	131A			
103E	4050	STH	5,MSICFG	
	131B			
1042	4050	STH	5,INSTFG	
	131C			
1046	4050	STH	5,INTRFG	
	131E			
104A	0850	LHI	5,GREAD	LOAD INTERRUPT ROUTINE D
	105C			
104E	4050	STH	5,X'46'	
	0046			
1052	0200	IEXIT LPSW	X'40'	
	0040			
1056	0200	IEXIT1 NOPR		
1058	4300	B	IEXIT1	WAIT LOOP
	1056			
105C	0850	GREAD LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011			
1060	9F56	AIR	5,6	ACKNOWLEDGE INTERRUPT
1062	9B58	RDR	5,8	READ DATA INTO R8
1064	4300	B	ARSTAT	
	1068			

## C-8

1068	0856	ARSTAT	LHR	5,6	STORE STATUS BYTE IN R6
106A	C450		NHI	5,X'8'	HANGUP FLAG SET?
	0008				
106E	4230		BNZ	HANGUP	YES
	10EC				
1072	0856		LHR	5,6	NO - LOAD STATUS BYTE
1074	C450		NHI	5,X'40'	DATA FLAG SET?
	0040				
1078	4230		BNZ	DSDATA	YES.
	1164				
107C	0856		LHR	5,6	NO - LOAD STATUS BYTE
107E	C450		NHI	5,X'4'	DATA SET READY FLAG SET?
	0004				
1082	4230		BNZ	DSRDY	YES.
	10D8				
1086	0856		LHR	5,6	
1088	C450		NHI	5,X'80'	ARU FLAG SET?
	0080				
108C	4230		BNZ	ARUINT	YES
	1110				
1090	0856		LHR	5,6	NO - LOAD STATUS BYTE.
1092	C450		NHI	5,X'20'	
	0020				
1096	4230		BNZ	INTRO	
	10A8				
109A	0856		LHR	5,6	NO-LOAD STATUS BYTE
109C	C450		NHI	5,X'10'	
	0010				
10A0	4230		BNZ	INST	YES
	10C4				
10A4	4300		B	IEXIT	
	1052				
10A8	C860	INTRC	LHI	6,1	SET YES/NO FLAG
	0001				
10AC	4060		STH	6,YNFLAG	
	131A				
10B0	C850		LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011				
10B4	C860		LHI	6,X'C'	ENABLE 1-NO. INPUT
	000C				
10B8	9E56		OCR	5,6	
10BA	C860		LHI	6,X'2'	ENABLE DATA INPUT
	0002				
10BE	9E56		OCR	5,6	
10C0	4300		B	IEXIT	
	1052				
10C4	C850	INST	LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011				
10C8	C860		LHI	6,X'2'	ENABLE DATA INPUT
	0002				
10CC	9E56		OCR	5,6	
10CE	C860		LHI	6,X'4'	ENABLE 2-NO. INPUT
	0004				
10D2	9E56		OCR	5,6	

## C-9

10D4	4300		B	IEXIT	
	1052				
10D8	C850	DSRDY	LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011				
10DC	C860		LHI	6,X'A'	DISABLE DATA INPUT
	000A				
10E0	9E56		OCR	5,6	
10E2	C860		LHI	6,X'5'	START INTRODUCTION
	0005				
10F6	9E56		OCR	5,6	
10F8	4300		B	IEXIT	
	1052				
10EC	C850	HANGUP	LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011				
10F0	C860		LHI	6,X'B'	DISABLE ARU
	000B				
10F4	9E56		OCR	5,6	
10F6	C860		LHI	6,X'A'	DISABLE DATA INPUT
	000A				
10FA	9E56		OCR	5,6	
10FC	C860		LHI	6,0	
	0000				
110C	4060		STH	6,YNFLAG	
	131A				
1104	4060		STH	6,INTRFG	
	131E				
1108	4060		STH	6,INSTFG	
	131C				
110C	4300		B	IEXIT	
	1052				
1110	4860	ARUINT	LH	6,ARFLG2	ERROR CHECK FLAG SET?
	1322				
1114	C560		CLHI	6,1	
	0001				
1118	4330		BE	ARDATA	YES
	1140				
111C	086A		LHR	6,10	NO - LOAD END OF LIST FB
111E	4460		NH	6,DACN1	END OF LIST?
	1324				
1122	4230		BNZ	GWRITE	NO
	1260				
1126	C850	ARINT1	LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011				
112A	C860		LHI	6,X'B'	DISABLE ARU
	000B				
112E	9E56		OCR	5,6	
1130	C860		LHI	6,X'2'	ENABLE DATA INPUT
	0002				
1134	9E56		OCR	5,6	
1136	C860		LHI	6,X'4'	ENABLE 2-NO INPUT
	0004				
113A	9E56		OCR	5,6	
113C	4300		B	IEXIT	
	1052				

## C-10

1140	4860	ARDATA	LH	6,ARFLG1	LOAD COUNTER
	1320				
1144	C560		CLHI	6,1	FIRST TIME AROUND
	0001				
1148	4330		BE	ARDA1	NO
	1158				
114C	C860		LHI	6,1	YES - SET COUNTER
	0001				
1150	4060		STH	6,ARFLG1	
	1320				
1154	4300		B	1EXIT	
	1052				
1158	C860	ARDA1	LHI	6,0	RESET DATA CHECK FLAG
	0000				
115C	4060		STH	6,ARFLG2	
	1322				
1160	4300		B	ARINT1	
	1126				
1164	C850	DSDATA	LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011				
1168	C860		LHI	6,X'A'	DISABLE DATA INPUT
	000A				
116C	9E56		OCR	5,6	
116E	4860		LH	6,YNFLAG	LOAD YES-NO FLAG
	131A				
1172	C560		CLHI	6,1	YES-NO FLAG SET?
	0001				
1176	4330		BE	YNDATA	YES
	123A				
117A	0848		LHR	4,8	NO - LOAD INPUT DATA
117C	C580		CLHI	8,X'40'	ERROR INDICATOR?
	0040				
1180	4330		BE	ARUERR	YES
	12A8				
1184	0884		LHR	8,4	LOAD DATA
1186	C580		CLHI	8,X'70'	REPEAT MESSAGE?
	0070				
118A	4330		BE	ARUEM1	
	128F				
118E	4860		LH	6,PDATA	LOAD PREVIOUS INPUT DATA
	1326				
1192	4160		BAL	6,IINPUT	PUT DATA ON LIST
	12B0				
1196	0884		LHR	8,4	LOAD DATA
1198	C580		CLHI	8,X'50'	ECM FLAG SET?
	0050				
119C	4330		BE	ARUECM	YES
	128A				
11A0	0884		LHR	8,4	LOAD DATA
11A2	C580		CLHI	8,X'60'	POINT INDICATOR?
	0060				
11AG	4330		BE	1POINT	YES
	122A				
11AA	0884		LHR	8,4	NO - LOAD DATA

## C-11

11AC	C480		NHI	8,X'30'	NUMBER INPUT?
	0030				
11B0	C580		CLHI	8,X'30'	30-39 = NUMBER INPUT
	0030				
11B4	4230		BNE	ARCHAR	NO - A CHARACTER WAS INB
	11D0				
11BE	0884	ARUNUM	LHR	8,4	
11BA	C460		NHI	8,X'F'	MASK FIRST 4 BITS
	000F				
11BE	0868		LHR	6,8	
11C0	CA80		AHI	8,X'1E'	CONVERT TO ARU ADDRESS
	001E				
11C4	CA60		AHI	6,X'30'	CONVERT TO ASCII
	0030				
11C8	4060		STH	6,PDATA	
	1326				
11CC	4300		B	DADATI	
	120E				
11D0	0884	ARCHAR	LHR	8,4	
11D2	C440		NHI	4,X'F0'	MASK OFF LAST 4 BITS
	00F0				
11D6	C540		CLHI	4,X'20'	20-26 INPUT?
	0020				
11DA	4330		BE	TWENTY	YES
	11FA				
11DE	C540		CLHI	4,X'10'	10-19 INPUT?
	0010				
11E2	4330		BE	TEN	YES
	11EA				
11E6	4300		B	ZERO	NO - 1-9 INPUT
	11F2				
11EA	C840	TEN	LHI	4,X'A'	CONVERT TO ARU ADDRESS
	000A				
11EE	4300		B	NUMBER	
	11FE				
11F2	C840	ZERO	LHI	4,0	CONVERT TO ARU ADDRESS
	0000				
11F6	4300		B	NUMBER	
	11FE				
11FA	C840	TWENTY	LHI	4,X'14'	CONVERT TO ARU ADDRESS
	0014				
11FE	C480	NUMBER	NHI	8,X'F'	MASK OFF FIRST 4 BITS
	000F				
1202	0A84		AHR	8,4	
1204	0848		LHR	4,8	LOAD DATA INPUT
1206	CA40		AHI	4,X'41'	CONVERT TO ASCII
	0041				
120A	4C40		STH	4,PDATA	STORE INPUT DATA IN ASCII
	1326				
120E	C860	DADATI	LHI	6,'3'	EVOLVE ARU
	0003				
1212	9E56		OCR	5,6	
1214	9A58		WDR	5,8	EVOLVE TO ARU
1216	C860		LHI	6,0	LOAD COUNTER AT ZERO

## C-12

121A	0000 4060 1320	STH	6,ARFLG1	
121E	C860 0001	LHI	6,1	LOAD ERROR CHECK FLAG AT
1222	4060 1322	STH	6,ARFLG2	
1226	4300 1052	B	IEXIT	
122A	C880 0028	IPOINT LHI	8,40	LOAD ARU ADDRESS
122E	C840 002E	LHI	4,X'2E'	LOAD ASCII FOR .
1232	4040 1326	STH	4,PDATA	PLACE IN TEMP. STORAGE
1236	4300 120E	B	DADAT1	
123A	C580 0010	YNDATA CLHI	8,X'10'	YES INPUT?
123E	4330 124E	BE	YDATA	YES
1242	C860 0000	NDATA LHI	6,0	RESET YES-NO FLAG
1246	4060 131A	STH	6,YNFLAG	
124A	4300 10C4	B	INST	
124E	C860 000D	YDATA LHI	6,X'D'	START INSTRUCTIONS
1252	9E56	OCR	5,6	
1254	C860 0000	LHI	6,0	CLEAR YES-NO FLAG
1258	4060 131A	STH	6,YNFLAG	
125C	4300 1052	B	IEXIT	
1260	4860 1316	GWRITE LH	6,TOPFLG	LOAD POINTER
1264	CA60 0002	AHI	6,2	MOVE POINTER DOWN 1
1268	C560 1354	CLHI	6,BOTTOM	END OF LIST?
126C	4330 1282	BE	GWRIT1	YES
1270	4060 1316	STH	6,TOPFLG	NO - STORE NEW POINT
1274	C850 0011	LHI	5,X'11'	LOAD DEVICE ADDRESS
1278	4846 0000	LH	4,0(6)	LOAD DATA FROM TABLE
127C	9A54	WDR	5,4	WRITE DATA TO ARU
127E	4300 1052	B	IEXIT	
1282	C8A0	GWRIT1 LHI	10,0	SET END OF LIST FLAG

## C-13

1286	0000				
	4300	B	1EXIT		
	1052				
128A	4140	ARUEOM	BAL	4,MUSIC	
	1282				
128E	C850	ARUEM1	LHI	5,X'11'	LOAD DEVICE ADDRESS
	0011				
1292	C860		LHI	6,X'3'	ENABLE ARU
	0003				
1296	9E56		OCR	5,6	
1298	C8A0		LHI	10,1	
	0001				
129C	C860		LHI	6,TOP	RESET MESSAGE POINTER
	1328				
12A0	4060		STH	6,TOPFLG	
	1316				
12A4	4300	B	GWRITE		
	1260				
12A8	C880	ARUERR	LHI	8,50	LOAD ARU ADDRESS
	0032				
12AC	4300	B	DADAT1		
	120E				
12B0	0306	IINPUT	BR	6	
12B2	C850	MUSIC	LHI	5,X'11'	LOAD DEVHCE ADDRESS
	0011				
12B6	C860		LHI	6,X'1'	START MUSIC
	0001				
12BA	9E56		OCR	5,6	
12BC	C860		LHI	6,X'3'	ENABLE ARU
	0003				
12C0	9E56		OCR	5,6	
12C2	9D56	MUSIC1	SSR	5,6	
12C4	C460		NHI	6,X'80'	ARU INTERRUPT?
	0080				
12C8	4330	BZ	MUSIC1		
	12C2				
12CC	4860	LH	6,MSICFG		
	1318				
12D0	CA60	AHI	6,1		
	0001				
12D4	4060		STH	6,MSICFG	
	1318				
12D8	C560	CLHI	6,X'28'		
	0028				
12DC	4230	BNE	MUSIC1		
	12C2				
12E0	C860		LHI	6,X'2'	
	0002				
12E4	9E56		OCR	5,6	
12E6	C860		LHI	6,X'9'	TURN OFF MUSIC
	0009				
12EA	9E56		OCR	5,6	
12EC	C860		LHI	6,0	
	0000				

C-14

12F0	4060		STH	6,MSICFG	CLEAR COUNTER
	1318				
12F4	C420		LHI	2,X'0'	
	0000				
12F8	9D56	MUSIC2	SSR	5,6	
12FA	C460		NHI	6,X'80'	
	0080				
12FE	4330		BZ	MUSIC2	
	12F8				
1302	CA20		AHI	2,X'1'	
	0001				
1306	C520		CLHI	2,X'4'	
	0004				
130A	4230		BNE	MUSIC2	
	12F8				
130E	C860		LHI	6,X'A'	
	000A				
1312	9E56		OCR	5,6	
1314	0304		BR	4	
1316		TOPFLG	DS	1	
1318		MSICFG	DS	1	
131A		YNFLAG	DS	1	
131C		INSTFG	DS	1	
131E		INTRFG	DS	1	
1320		ARFLG1	DS	1	
1322		ARFLG2	DS	1	
1324		DACN1	DS	1	
1326		PDATA	DS	1	
1328	0000	TOP	DC	X'0'	
132A	0000		DC	X'0'	
132C	0033		DC	H'51'	BOOK
132E	0035		DC	H'53'	IS OUT
1330	0000		DC	H'0'	SPACE
1332	003B		DC	H'59'	DUE DATE
1334	000C		DC	H'44'	JULY
1336	0020		DC	H'32'	2
1338	001E		DC	H'30'	0
133A	0000		DC	H'0'	SPACE
133C	001F		DC	H'31'	1
133E	0027		DC	H'39'	9
1340	0024		DC	H'36'	6
1342	0027		DC	H'39'	9
1344	0000		DC	H'0'	SPACE
1346	003C		DC	H'60'	BORROWER
1348	0004		DC	H'4'	D
134A	001F		DC	H'31'	1
134C	0023		DC	H'35'	5
134E	001F		DC	H'31'	1
1350	001F		DC	H'31'	1
1352	001F		DC	H'31'	1
1354	0000	BOTTOM	DC	H'0'	0
1356			END	ARINIT	

ARCHAR 11D0

ARDA1	1158
ARDA2	1140
ARFLG1	1320
ARFLG2	1322
ARINIT	1000
ARINT1	1126
ARSTAT	1068
ARUEM1	128E
ARUEOM	128A
ARUERR	12A8
ARUINT	1110
ARUNUM	11B8
POTOM	1354
DACN1	1324
DADAT1	120E
DSDATA	1164
DSRDY	10D8
GREAD	105C
GWRT1	1282
GWRITE	1260
HANGUP	10EC
IEXIT	1052
IEXIT1	1056
IINPUT	12B0
INST	10C4
INSTFG	131C
INTRFG	131E
INTRO	10A8
IPOINT	122A
MSICFG	1318
MUSIC	12B2
MUSIC1	12C2
MUSIC2	12F8
NDA1	1242
NUMBER	11FE
PDAT1	1326
TEN	11FA
TOP	1328
TOPFLG	1316
TWENTY	11FA
YDATA	124E
YNDATA	123A
YNFLAG	131A
ZERO	11F2

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14. ABSTRACT

This document describes the development of an audio response unit on an automated on-line real-time library circulation system connected to the Dartmouth G.E. 635 time-sharing computer. The function of the audio response unit is to provide audio output in response to input through a touch-tone telephone button pad under the Library System Controller. The unit has been constructed and is in operation.

FORM

1473